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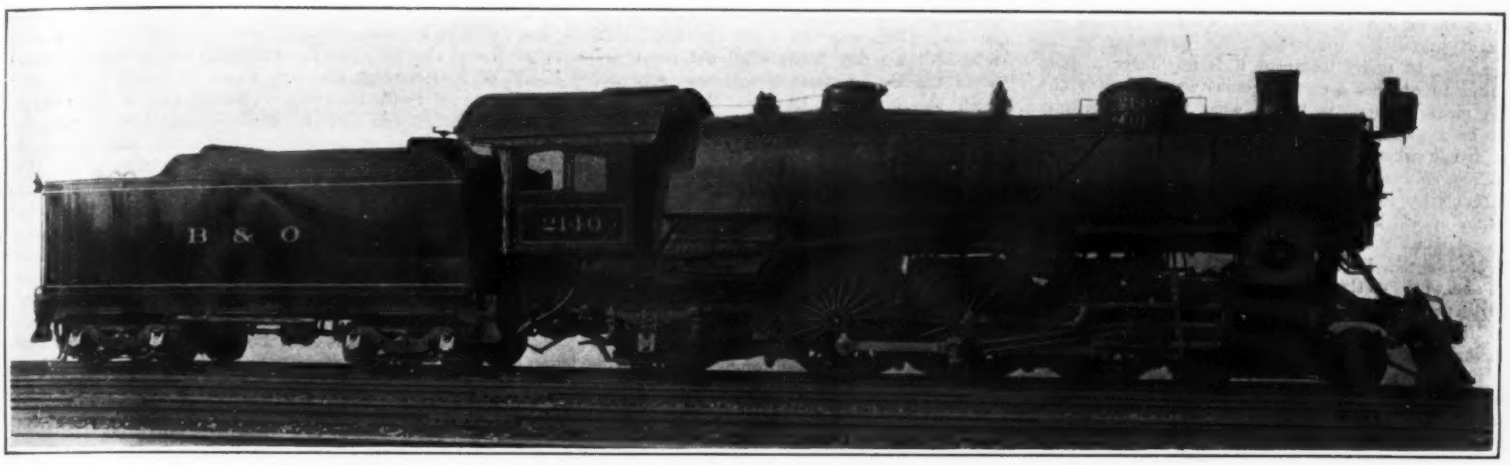

Fig. 1.—Pacific Type Locomotive. The Standard for Heavy Trains at High Speeds.

Fig. 2.—Mikado Type Passenger Locomotive. Very Successful for Service on Steep Grades.

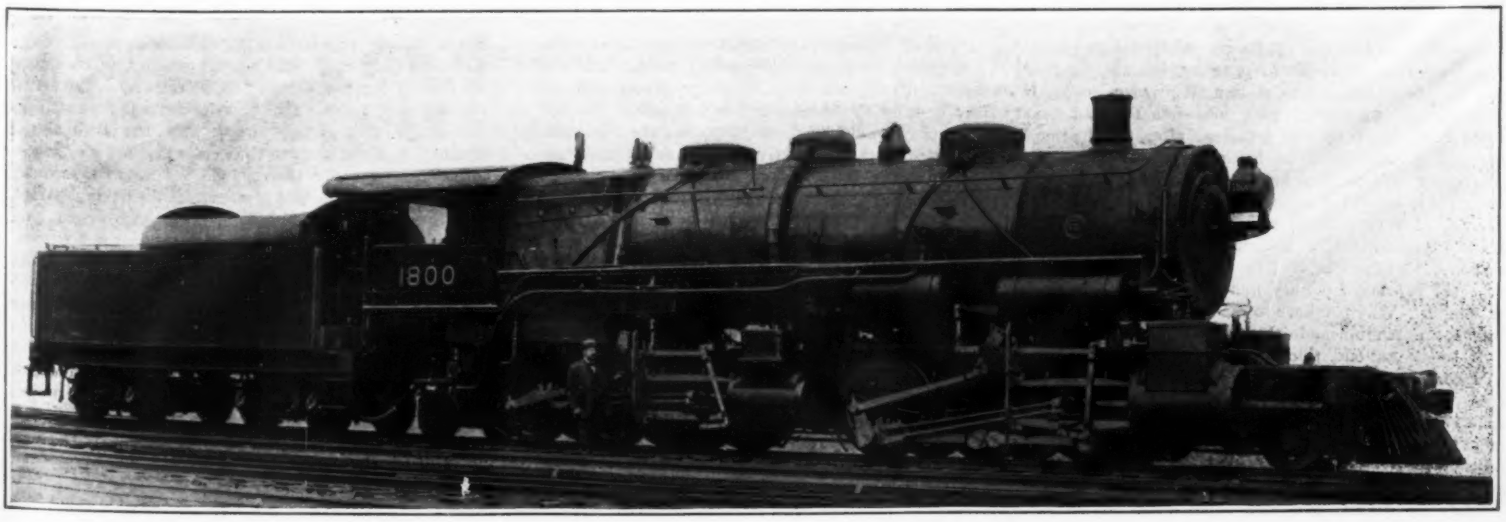

Fig. 3.—Mallet Locomotive. The Articulated Type Must be Resorted to When the Number of Driving Wheels Exceeds Ten.

RECENT DEVELOPMENT IN THE LOCOMOTIVE.—[See page 8.]

Literary Genius and Manic-Depressive Insanity*

With Special Reference to the Alleged Case of Dean Swift

By Arthur C. Jacobson, M.D.

There is a strong disposition among many writers to postulate the essential "insanity of genius." In the *Medical Record*, June 15th, 1912, there occurs the statement that "apparently no writer can dare to aspire to literary distinction without running the risk of submitting to psychological dissection by the alienists. In many instances it is no longer a question as to whether a certain genius was insane or not. The modern query is 'From what form of insanity did he suffer?'" These remarks were prompted by an article which recently appeared in the *American Journal of Insanity*, under the title, "Manifestations of Manic-Depressive Insanity in Literary Genius," the author of which, Dr. Eva Charlotte Reid, one of the physicians at the Government Hospital for the Insane at Washington, D. C., sets forth that the study of the life and works of the literary genius would indicate that the literature was incidental to the psychosis and simply formed an outlet for the abnormal feelings and passions of the writer. This mental disease, it will be remembered, is marked by alternations of elation and depression, of frenzy and despair, of mania and melancholia, and Dr. Reid discerns in the writings of many of our greatest authors much evidence that they experienced such emotional turmoil. She draws the conclusion that they were victims of manic-depressive insanity and that their infirmity was the motive force that drove them on to more or less glorious expression. "With an emotional instability which raises him (the literary genius) to the pinnacle of exaltation one day and plunges him into the depth of despair the next, his industry must be spasmodic." Unable to adapt himself to his surroundings, "in his literature he finds an outlet for all his abnormal feelings and passions. Here he pours forth, under various guises, his rapturous joys and fears, his dreams of bliss, and his dread of impending calamity. The manifestations of his abnormal mental condition, which are denied him in actual life, find an outlet in poetry and fiction, under the guise of literary and poetical inspiration."

The present writer finds it difficult to lend his intellectual sympathy to such a thesis, which practically amounts to claiming that geniuses are geniuses *because* they are insane. There is a vast amount of evidence showing a family history of insanity or degeneracy of some sort in the case of many, if not most, of the greatest geniuses, and such geniuses are unquestionably more likely to become insane than are less highly organized people, and do so become very frequently indeed, but the writer contends that these facts in no way justify such assumptions as those of Dr. Reid, and the great majority of writers who have occasion to touch upon the subject of genius. A watch is not built to withstand lawn-mower usage. And it must not be forgotten that literary geniuses differ from most subjects of psychological or psychiatric study in that they have written themselves down, so to say. Their hopes and fears, in some cases, like Rousseau, all their inner lives, are recorded. Who shall say that the emotional reactions portrayed are so vastly different in kind or in degree from those of other noble but less expressive minds under special stress? Then we ought to consider the adequacy of the factors entering into elation, depression, etc. If Swift was downhearted after his virtual banishment from England, if he was depressed after the death of his dearest friends, if he became choleric under the grievously hard political knocks he received from bitter enemies, if he was a sufferer from arteriosclerosis after the age of twenty-three, why must we read into such facts manic-depressive insanity, any more than the response to adequate factors that might be expected to occur in such a mighty mind, or even in any first-rate mind? Why is failure to react strongly to adequate intellectual stimuli made the criterion of sanity?

It seems an odd thing to the writer that a great literature is not emanating from the asylums of the land, if it be true that the relation of genius and insanity is so close. The answer is that the great genius must be eminently sane. He must possess in the highest possible degree the critical faculty directed toward his own literary productions. No great literary work can possibly be produced if this endowment be lacking. Such a lack is one of the most marked characteristics of the insane. The mind that produced Hamlet was super-sane. To the critic who insists upon intellectual mediocrity and slow emotional reaction as the criteria of sanity, such a mind seems essentially insane. The "normal" man, says Dr. Reid, rises above the common ills of life, poverty, sickness and death, that is, is not greatly or for very long affected by them. It was the presence of such things around him in Ireland, in superlative degree, that inspired the best efforts of the greatest of English satirists. The writer would say that Swift was the most "normal" man in the Ireland of his day because he did react so strongly to the terribly adequate factors that surrounded him, which reaction gave us the "Drapier Letters" and awoke his compatriots from their moribund state. It is the abnormality of the social masses of to-day, and not their normality, that precludes an effective reduction of infant mortality. Those who realize the appalling conditions and are fighting them are not victims of manic-depressive insanity, either. No critic with only a partial sense of humor ought to examine the writings of literary geniuses with a view to their conviction on the score of manic-depressive insanity. To one in whom this sense is somewhat atrophied or absent De Quincey's "Murder as One of the Fine Arts" would certainly seem brimful of manic-depressive evidences. De Quincey, it is true, is cited by Dr. Reid as one of the group of insane geniuses. Probably a study of this masterpiece on murder helped to the fatal conclusion. To our mind, the writing of such a piece of literature is conclusive proof of super-sanity.

Dr. Reid confesses that Swift's brilliant satire, "A Modest Proposal for Preventing the Children of Poor People in Ireland from Being a Burden to Their Parents or Country," convinced her of his insanity. She not only betrays a total lack of the ironic humor sense, but she is either unfair or grossly uninformed as to the circumstances in which the "Modest Proposal" was written. The piece in question was written in 1729, after Swift's final break with Walpole. It is a wonderful piece of sustained irony, suggesting with a ghastly vividness the horrible state of the Irish people, whose champion Swift was. In studying it we must take into consideration the frightful conditions that inspired it, the motive of the writer, and its political effect. When this is done it will be seen very clearly to have been justified. Read in ignorance of such considerations, the piece might seem a diabolical fantasy. As a plain matter of fact it proved one of the most effective efforts of the great satirist. And it was only one of a long series of powerful attacks upon the indefensible English policy in Ireland against which Swift contended with all his tremendous intellectual power.

Lecky appraised the celebrated piece of humor the inspiration of which we have discussed at its proper value, and Sir Walter Scott saw in it nothing worse than "inimitable gravity of irony," relating with keen amusement how a foreign author had seriously accepted Swift's proposal that the rich English feed upon the poor Irish. But Dr. Reid is quite blind to its political and sociological significance and can only say: "Many of his (Swift's) writings could only be the productions of an insane mind. For instance, in a pamphlet entitled 'A Modest Proposal for Preventing the Children of Poor People in Ireland from Being a Burden to Their Parents or Country,' he suggests that these children be fattened, sold to the wealthy, killed, their bodies used for food, and their skins for gloves and shoes. He dilates in the most horrible manner on the age at which they would be most palatable, the best manner of cooking, and the relative values at different ages."

Sir William Wilde, after a study of the available data, declared that there was no proof that Swift had ever been insane, and that his peculiarities in later life were due to the ordinary decay of nature. The opinion of this eminent Irish physician is conclusive.

A recent writer on true neurasthenia recites as leading emotional symptoms ill-humor, unreasonableness, peevishness, irritability, impetuousness and a tendency to fault-finding, trifling occasions leading to outbursts of temper; a prevailing mood of depression and despondency is characteristic of these sufferers; frigidity or sexual impotence is frequently observed. Swift had all of these traits and the diagnosis may well stop short in his case at neurasthenia. Dr. Reid's citation of such traits amounts practically to an attempt to show that Swift ought to have been insane, even if he were not, but nothing beyond the implication of neurasthenia can be tortured out of them. That he should have been a neurasthenic is quite understandable, when one considers the man's stormy political life, and ill health, as well as his misfortunes in general, and what might be called his involuntary failure as an ecclesiastic. He was not the first man, and will not be the last, to be suspected of insanity because he ferociously and effectively assailed political corruption. For a considerable period, before his exile to Ireland, land of his birth and education, he controlled English public opinion more than any other man, and was influential to that degree that he became the most powerful defender and counsellor of the Tory party, leading the way to the dismissal of Marlborough and the Peace of Utrecht. In the case of Swift we are not dealing with a second-rate character, nor with a lunatic of any kind or degree, but with one of the greatest men of all time, possessed of marked defects easily lending themselves to the grossest exaggeration, and of traits that made him feared or hated by the pygmies and knaves of his own day and the "tin horn" critics of posterity. He was "the most tragic figure in the literature of the eighteenth century, the only man of his age who could be conceived as affording a groundwork for the creations of Shakespeare." One smiles in his case when he reads Dr. Reid's dictum that the industry of the victim of manic-depressive insanity must be spasmodic. There was nothing spasmodic about the indefatigable and continuous labors of the author of "Gulliver's Travels." One laughs in his case when he learns from Dr. Reid that the manic-depressive genius is unable to adapt himself to his surroundings and that it is this which leads to the selection of literature as an outlet for the thoughts that he has spun in his own unreal world. Swift had "an eminently practical mind, seizing with a happy tact the common-sense view of every question he treated, and almost absolutely free from the usual defects of mere literary men." (Lecky.)

The writer has spoken of Swift's arteriosclerosis. At the age of twenty-three he began to suffer from dizziness and ringing in the ears. As he grew older his querulousness, irritability, and other symptoms increased. We are well aware to-day of the relationship sustained between arteriosclerosis and neurasthenia. The autopsy that was made after Swift's death disclosed cerebral shrinkage and arteriosclerosis. Dr. Reid claims that the aural symptoms marked the beginning of the psychosis from which she alleges he suffered. The terminal breakdown at the age of seventy-three (death came five years later) Dr. Reid calls an "engrafted arteriosclerotic dementia." To the writer's mind, Swift's case typified arteriosclerosis as Osler and other observers have noted this condition in the very young, the symptoms of cerebral neurasthenia therefore resting upon an organic basis, a relationship which has been dwelt upon particularly by Stengel. Being a simple and sensible view, based upon known facts interpreted in a non-sensational way by one who is not a professional alienist obsessed by the bizarre doctrine that postulates the essential insanity of genius, it may not appeal to the lovers of the *outré*. Let us discourage all such doctrines of the crowd, lacking as they do any sound or even defensible psychiatric basis.

That the true genius is necessarily crazy is essentially a vulgar view, fostered, apparently, by every intellectual plebeian. It is high time that it be shattered. There is a failure to distinguish between the insane temperament and actual insanity. Too fine a distinction for the bourgeoisie of science, it nevertheless is a vital point. Still finer for them is the fact that the insane temperament itself, only less than actual insanity, is a handicap to the genius and not his "motor force." It is easier to conclude the essential insanity of genius and save a deal of sound, hard thinking. Why, say these short-cut philosophers to the writer, you yourself admit insane family history, insane temperament, and the frequent occurrence of insanity. What are you driving at?

Genius makes for insanity, but neither insanity nor the insane temperament makes for genius. The genius is usually, if not always, of insane temperament, but his best creative work reflects the man at his best, that is to say, sanest. To the degree that clinical insanity enters in, to that degree is his work vitiated. Insanity is the Nemesis of the delicately balanced genius, never his good angel. He does his work not because of, but in spite of, the Damoclean sword. The genius differs from other men in that he presents a curious capacity for superlative sanity alongside a similar capacity for insanity. Certain psychopathological states, undoubtedly at times excite and color the creative labors of true geniuses, but they are not geniuses because of the psychopathology. The fundamental quality of mind is *sui generis* and the thesis of Dr. Reid utterly fallacious. **Genius is not a disease.**

* *Medical Record.*

War and the Survival of the Fittest—I*

Does Physical Conflict Between the Nations Select the Highest Type?

By Robert M. Dickie

EVOLUTIONISTS who are accustomed to magnify the office of natural selection as a key to every problem, look upon war as the final expression of a law wrought into all life. They point out that during the long history of life from its earliest dawn upon our planet there has been a struggle for existence in which the weaker and less fit have gone to the wall and the superior type has survived and perpetuated itself. "Nature red in tooth and claw" has "with ravine shrieked" from the beginning. But, despite all this apparently immeasurable waste and cruelty, there has been through this process a gradual improvement of the types of life. The unfit have gone to the wall and left no descent, whereas the fit have survived and brought forth after their kind. The struggle for existence, turning nature into a shambles as it has, has yet been the mother of progress. In this prodigality of cruelty and death there is to be traced the history of life mounting to ever higher forms. Natural selection, we are assured, has been wrought into life from the beginning and is the sacred instrument of progress.

All life, we are assured, is of a piece and within the grip of this all-embracing law. It is true of human life as of lower orders. When we come to the history of man we find such a struggle in the first dawn of savage life in which the stronger and more resolute and crafty survive. We have but mounted higher in the order of life, we have not escaped its law and the condition of its progress. As it is with individuals so it is with communities of life. This natural warfare is arrested among certain individuals in the interest of their common social life. But presently instead of individuals, we have communities, families, tribes, races, at war. Here also conflict is the condition of progress. Those primitive societies in which the "social tissue" or solidarity of life was most highly developed, vanquished their fellows and either exterminated them or made them their hewers of wood and drawers of water as best served their purpose. These early tribal wars were thus a process of selection in which the weaker and less fit were eliminated and the strongest survived.

Nations and empires are simply larger communities of life subject to the same law. They must struggle one with the other, and out of that struggle comes progress. The unfit go to the wall, the fit survive. "Storm purifies the air and destroys frail trees, leaving the sturdy oaks standing. War is the test of a nation's political, physical and intellectual worth. The state in which there is much that is rotten may vegetate for a while in peace, but in war its weakness is revealed." (Prof. Baron Karl von Stengel in "Weltstaat und Freidensproblem"). "National entities in their birth, activities and death are controlled by the same laws that govern all life-plant, animal or national, the law of struggle, the law of survival. These laws so universal as regards life and time, so unalterable in causation and consummation, are only variable in the duration of national existence as the knowledge of them and obedience to them is proportionately true or false. Plans to thwart them, to shortcut them, to circumvent, to cozen, to deny, to scorn and violate them is folly such as man's conceit alone makes possible. Never has this been tried, and man is ever at it, but that the end has been gangrenous and fatal." (Gen. Homer Lea in "The Valor of Ignorance"). The argument from biology is thus twofold; war is the inexorable law of life which only stupidity will challenge and the sacred instrument of life's evolution which we all must revere.

But the terms "struggle for existence," "natural selection" and "survival of the fittest" lend themselves, in popular speech, to loose and indefinite use. It is easy to read "struggle for existence" as mortal combat between the different forms of life through all their ascending orders. Thus, we picture the early history of life as a warfare in which every individual had to fight every other individual that happened the same way and in which the strongest survived. But this is to misread the term as used in biological theory, and to this misreading much of the plausibility of the above argument is due.

The struggle for existence is indeed the law of all life. To live means to maintain a certain correspondence with nature. Life continues only so long as such an adaptation is maintained. This necessity laid upon an organism to maintain a correspondence with nature in order to live makes all life a struggle for existence. It is also the mother of invention and the mainspring of progress, for perfection of life is measured by the perfection of the organism's adaptation to its environment. But this struggle for existence is essentially a struggle of the organism with its environment, and goes on even where organisms of like kind live at peace with one another. Struggle between individual organisms is not necessary to natural selection, at most it is only incidental to it.

The environment with which an organism must struggle in order to adapt itself may, and usually does, include other like organisms as well as natural forces. The argument of the militarist drawn from biological theory assumes that the struggle for existence is essentially a struggle of one form of life with another, whereas it really is, in its essence, a struggle of life with its environment. It further assumes that the organism must struggle and contend with such other organisms as belong to its environment. But this assumption is neither true to fact nor essential to biological theory.

Not all forces either inorganic or organic in the organism's environment must be contended against in order to live. The lizard does not contend with the warm sun which freely shines upon it and contributes to its vital force, though it has to protect itself as best it can against the frost. The frost is his natural enemy and he has to contend against it, but the warm sun is his friend, he must welcome it. With respect to the inorganic elements of an organism's environment, it is altogether misleading to speak of their having to be contended with in order to live. Some elements are inimical to life and health and others are conducive to them. Against the former the organism struggles and resists as best it can; with the latter it co-operates. In relation, then, to the natural forces to which life must adapt itself, struggle, in the sense of contending against, expresses only one side of the organism's attitude toward its environment, and that the negative or defensive side; the other and positive side and that from which alone progress may be expected is to be expressed by the term co-operation.

Nor is it otherwise in the case of the organic part of an organism's environment. If a life had to contend with every other life that came within its environment it is as difficult to see how any life could survive as it would be if every inorganic force which touched a life were inimical to it. If that were the rule, parents would devour their offspring and there would be nothing to survive. But this is not the rule of nature; and not only so, but it is not the rule among the orders of lower life which come under our observation that a life lives at war with other lives of its kind within its environment. "Dog does not eat dog" and tiger does not hunt tiger. Such conflicts as do occur, usually over mating and food, may be described as incidental but not necessary to life. In the case of animals that mate in pairs there may be a conflict between males, but in such cases the weaker is not usually killed but simply forced to choose another mate. In the case of conflict over food the result is usually to scatter the contending parties over a wider area of territory, that is, to remove the one out of the environment of the other, and what one gains in ferocity and insolence the other gains in craftiness. I am not here concerned with lives of a different species which come within an organism's environment and are a menace to its life, for the theory of natural selection is primarily concerned with the struggle for existence among individuals of one kind or species, and the point to be insisted upon is that among the lower orders of life war is not the necessary and universal rule. An organism does not come into the world fighting, spend its brief span fighting and die fighting its own kind which come within its environment.

There is another feature in the relation of an organism to other organisms of its kind in its environment which appears comparatively early in the history of ascending life and which is of the utmost importance in the light of social organization. The relation of the organism to positive and favorable forces of nature in its environment we have described as co-operation. Very early in the history of life there appears another and higher manner of co-operation, the co-operation between an organism and similar organisms in its environment. The struggle of an organism to adapt itself to the conditions of existence is of the essence of all life. The system of natural forces among which it lives is absolutely impassive so far as the life which lives upon them is concerned. But when similar organisms possessed of similar capacities for adaptation become a part of life's environment we have entered upon a new phase of life and become aware of a new form of co-operation, not now the co-operation of a vital life-conserving energy with a blind purposeless force of nature, of organic with inorganic nature, but the co-operation of life with life. Now it becomes possible for the environment of the individual life positively and purposely to minister to the maintenance and enrichment of its life. Life-conserving purpose is both in the organism and its environment. This is to be seen in the attitude of very primitive types of life toward their offspring. The jealous care and protection given by the tigress to her cubs and the solicitude of the eagle in teaching her young to fly remind us that even in the fiercest types of life there is more than heartless ferocity and selfishness. Under the guidance of sex instinct lower orders of life co-operate in the struggle for existence both for their own mutual advantage and that of their offspring. Male and female in the early types of life have been helpers the one of the other in their struggle against common enemies. Here we have the beginnings of community life, the promise and potency of all social life. The extent to which such co-operation of organism with organism in a community life may be carried among the lower orders of life is to be seen, for instance, in an ant-hill or a bee-hive.

Then the argument from biology which says that the warfare of life with life is a universal law holding all life within its grip is not true to fact. Life is everywhere at war only with the forces in its environment which are inimical to it. When other organisms come within an individual's environment they are sometimes its enemies but sometimes its friends. Co-operation of life with life is as much a fact as the struggle of life with life and becomes increasingly common as we mount up in the scale of life. The other argument which says that this struggle for existence is the instrument by which progress in type of life is achieved confuses the struggle of life with nature with that of life with life. In the essential struggle for existence it is not the stronger type which pushes the weaker to the wall, but nature itself with which they fail to make a satisfactory adjustment. The process by which the weaker are eliminated and the fit permitted to survive and perpetuate their kind does insure progress but the struggle of life with life is not essential to it; at most it is only incidental.

(*To be continued*)

* Reproduced from *Queen's Quarterly*.

Use of Mirror in Watching Stack Smoke

ST. LOUIS has a strict smoke-prevention ordinance, and the fireman who shovels coal carelessly, with consequent clouds of black smut from the stack, is likely soon to find the firing aisle blocked by a couple of bluecoats with shining nickel-plated stars. The ordinance has been of assistance to the Union Electric Light and Power Company in transferring isolated plants to its care, where they receive scientific, intelligent supervision. For instructing its firemen in proper coaling and methods at the old Imperial district-heating plant, Tenth and St. Charles Streets, a 36-inch by 36-inch plate-glass mirror has been mounted on a framework in the yard outside the boiler room, so that the top of the smokestack can be seen from any point in front of the boilers. Rigelmann's charts of smoke density are posted conveniently near, and the fireman can take observations from time to time without leaving his station.—*Electrical World.*

Artificial Ebony from Oak Wood

CONSUL WILLIAM H. HUNT, St. Etienne, France, describes the following as a good process for converting oak wood to artificial ebony: The blocks of wood are immersed for 48 hours in a warm saturated solution of alum and sprinkled several times with a decoction of logwood; smaller pieces may also be steeped for a certain length of time in the decoction, which is prepared in the following manner: One part of logwood of best quality is boiled with 10 parts of water; it is then filtered through linen and the liquid evaporated at low temperature until its volume is reduced by one half, and to every quart of this bath are added 10 to 15 drops of a saturated solution of soluble indigo entirely neutral in reaction. After having watered the blocks several times with this solution, the wood is rubbed with a saturated and filtered solution of verdigris in warm concentrated acetic acid, and this operation repeated until a dark color of the desired intensity is obtained. The oak wood dyed after this fashion presents an aspect similar to that of real ebony.

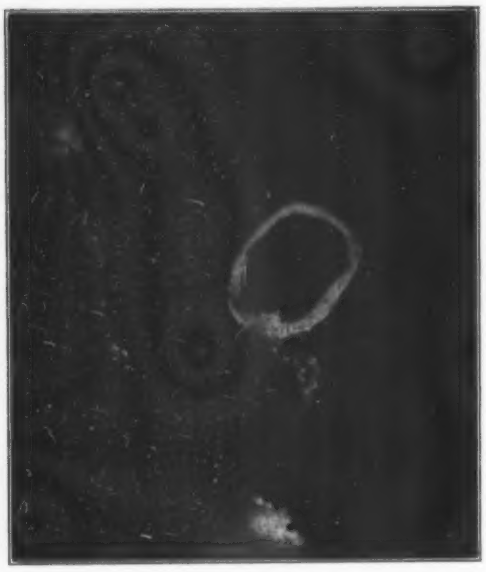

Fig. 1.—Smoke Ring Blown by Mount Etna in the Eruption of 1910.

Volcanic Vortex Rings*

and

The Direct Conversion of Lava Into Ash

By

Frank I. Perret, K. I. C.

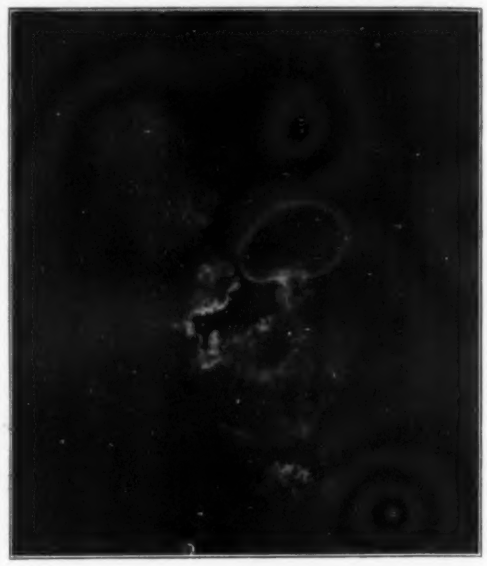

Fig. 2.—These Rings Measure Some 600 Feet in Diameter.

The vortex rings projected from cannon, locomotives, the mouth of a smoker, etc., are familiar to all. Sudden puffs from any smoke-filled cavity will produce, by interference at the edges of the orifice, visible annular vortices having a certain stability of form due to the persistence of the vortical movement. It is obvious, therefore, that the conditions necessary for the production of these rings must often obtain at volcanic craters and, in fact, such volcanoes as Vesuvius and Stromboli, during the prolonged periods of moderate activity which may be said to constitute their normal condition, project large, thin rings of vapor which frequently attain diameters of five hundred meters or more. Generally speaking, these are somewhat difficult to photograph because of their delicacy and lack of photographic contrast with the sky, and it was not until the Etna eruption of 1910 that the present writer observed volcanic vorex rings having a sufficient degree of solidity to permit of satisfactory photography. Figs. 1 and 2 show the type of rings projected at that time and of which the diameters were approximately 150 and 200 meters. It is not, however, with the purpose of discussing vortex rings, as such, that I have here referred to this phenomenon but because of the fact that these particular rings of the Etna eruption illustrate a principle of volcanic action which is of such importance as to merit attention at this time.

What impressed me most in observing these rings was the fact that they were composed almost entirely of ash and yet had been projected from a crater yielding liquid lava. This was the lowermost of the seven principal groups into which the twenty or more vents of this eruption were conformed and, according to my own enumeration, which has been generally adopted, viz., from the upper end of the fissure downward, it is known as crater No. 7.

The outflow of lava, which at the beginning had taken place at many points along the line of the fissure, was soon localized, as is normally the case, at the lowest principal opening, and this continued to be the source of the magnificent stream which formed so spectacular a feature of this eruption. (Fig. 6.)

The gas content of the magma caused a semi-explosive emission, projecting sprays and jets of incandescent liquid masses to a considerable height (Fig. 7), the result of which was the gradual building up of a cone of the compacted scoriæ, best seen in the post-eruption view (Fig. 5). It is important to note that neither the ejected fragments, nor the walls of the crater, nor the upper portion of the cone were "dry," i. e., hard or brittle, and therefore capable of being broken or crushed to powder—all were in the liquid or viscous state. There was no demolition of the cone itself, which was growing by accretion, and there was present no old material whatever, yet this crater constantly emitted a quantity of ash-laden vapor having a salmon-pink tint.

On the 30th of March at 6 A. M., the writer was proceeding along the line of eruptive mouths, when the rings shown in Figs. 1 and 2 were projected from crater No. 7. These had the same color as the other vapors and the air was full of a fine red ash having a strongly acid reaction. The large amount of this ash present in the air rendered obviously the aspect of the sun, which appeared as a ball of burnished copper, and was photographed without irradiation effects.

This production of ash continued along the first few hundred meters of the lava stream where the gases still escaped from the surface in considerable quantities. The gas emission under these conditions is apparently very gentle (Fig. 3), producing a continuous simmering sound analogous to that of water in a kettle just before ebullition, but it is probable that each tiny gas vesicle burst from the lava with an explosion *which, for its size, is violent*, and thus projects and carries off minute particles of the exploded shell.

It is this *subdivisional* gaseous expansion, and not the explosion of large bubbles, which is the cause of the formation of the ash.

The degree of viscosity of the lava is, in all probability, an important factor in this direct formation of ash, while secondary to the gas content as a determining cause. In the case we are considering, although the velocity of the stream at this locality was five meters per second and the mass as a whole showed all the qualities of a liquid, the viscosity was so great, especially in the outer layer, that a heavy rock thrown upon the surface rebounded as from a plate of steel, and it was only with the greatest difficulty that an iron rod could be forced into the moving stream. In the very liquid lavas of Hawaii the gas vesicles issue almost without resistance and do not form ash in this way, but large gas bubbles scatter the lava and spin it out into glassy filaments—the well known "Pele's Hair."

The present writer has often observed the same copper-colored cloud of gas and ash as produced directly from glowing lava in the central crater of Etna, and also in that of Vesuvius and Stromboli. A cloud of *white* vapor over the crater will also, even in daylight, under these circumstances, appear of a copper tint because illuminated by the glare of the lava below, but when ash is present the color of the cloud persists to all distances, as in the case of the Etna rings.

Let us now leave the consideration of the principle as exemplified in this superficial action, and study its function in the more fundamental processes of a great eruption. Taking the Vesuvian outbreaks of 1872 and 1906 as typical, and glancing at conditions at the outset, we find that as the result of a long period of moderate activity the cone has been built up to a considerable elevation above the crater of the preceding great eruption, and that the lava stands at a commensurately high level in the central conduit. At the initiation of the eruption the cone is fissured laterally by pressure, fusion and gas tension causing a rapid and copious outflow of lava. This is accompanied by a more or less complete demolition of the upper portion of the cone, the explosive effects at the central vent increase in violence, ejecting old and new material, and attain their maximum with the cessation of the lava

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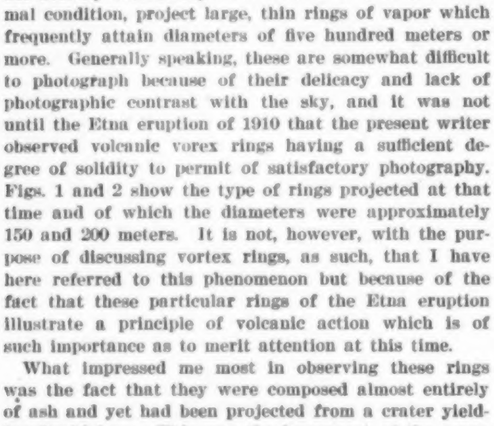


Fig. 3.—Here There Was a Comparatively Quiet and Steady Evolution of Gas, Producing a Continuous Simmering Sound.

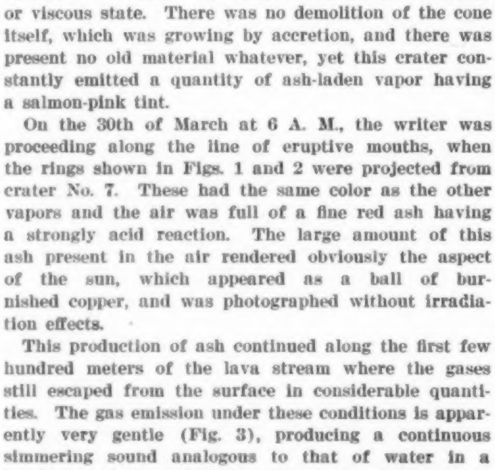


Fig. 4.—In This Type of Eruption a Stupendous Emission of Gas and Ash Proceeds from the Main Crater After the Flow of Liquid Lava Has Ceased.

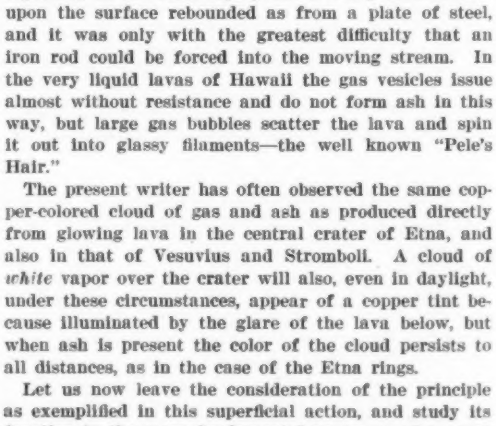


Fig. 5.—Post Eruptive View. The Scene as it Appeared When the Volcano Had Quieted Down, After Building up a Cone of Compacted Scoriæ.

outflow, to which there succeeds the truly stupendous emission of gas and ash from the main crater (Fig. 4)—no more liquid lava being seen.

But if, in such a case, we are asked to consider the liquid outflow and the explosive ejections as constituting the only emission of co-eval lava, and the ash as being merely old cone-material and triturated rock, as is quite generally supposed, then, I believe, I may raise a point of objection and interrogation.

Let us consider for a moment the condition of the magma in the deeper portions of the volcanic conduit. Its temperature will be higher and its gas tension greater than in the upper portion while it will be subjected to the pressure of the column above it. In these respects it is analogous, as I pointed out some years ago,[1] to the water in the lower portions of a geyser or to the water in a boiler under tension. This, by reason of the pressure upon it, is actually in liquid form, but it is potentially a vapor because of its temperature, and if the pressure is removed it will flash into the gaseous condition. Similarly, the lower zones of lava in the volcanic conduit are potentially in a condition of explosive extension and are maintained in a liquid or semi-liquid state only by the pressure from above. If now we imagine a relief of this pressure—say by a lateral outflow of lava sufficiently rapid and copious to materially reduce the height of the lava column—a powerful gaseous expansion will be initiated in the magma below and this will extend progressively downward with progressive relief of pressure from above. This gaseous development will be *distributed, subdivisional, intermolecular*, the magmatic mass expanding to a froth and being finally ejected as a cloud of gas and ash—it is impossible that it should appear in a liquid form under these conditions.

Note that this ash will have been formed under very different conditions from that which is blown off from the surface of the lava in the crater during the early part of the eruption. This latter is formed in contact with atmospheric air and is quickly cooled; it is, therefore, of a vitreous nature with surface oxidation. But the ash from the depths will have been formed in a bath of the magmatic gases, out of contact with the atmosphere, and at a temperature which is maintained for a considerable time. The difference between the two is, however, mainly physical, and the magmatic ash, if I may so call it, should also, by the very conditions of its formation, be *virtually identical*, as material, *with the co-eval lava*, i. e., its ingredients should be the same, it should carry the same salts, exhibit the same crystals under the microscope, give off the same gases on being heated, etc., which could hardly be the case if it were formed by the trituration of old and profoundly metamorphosed rock. The limits of the present paper will not permit of a full discussion of this important subject, but it may be noted that Palmieri,[2] writing of the Vesuvian ash of 1871 and 1872, refers to its identity of composition with the co-eval lavas, and Casoria's analyses of the 1906 products show this to a remarkable degree; it is evident that some of the old triturated material must be found in the ash, the present contention being that it does not constitute the bulk of it.

Considering this in connection with the fact that those who have attempted to calculate the total volume of material lost by the cone have generally considered it insufficient to account for the amount of ash emitted, we may fairly state the necessity of admitting the emission of co-eval magmatic material during the ash phase of the eruption.

It will be seen that this hypothesis does not in the least degree invalidate the division of the eruption into a "Strombolian" and a "Vulcanian" phase—on the contrary, it supplies a cause for the great and continued dynamism of the "Vulcanian" phase and explains the identity of its ash with the co-eval lava.

It is interesting to note that the "Vulcanian" phase, as far as actual, external eruption is concerned, is cooler than the "Strombolian." This is due, in part, to the downward removal of the furnace, i. e., the lava column, but also, most certainly to the enormous absorption of heat in the process of gaseous expansion in the deeper magma and the subdivision of the latter into minute particles which quickly assume the temperature of the gas which surrounds them. During the "Strombolian" phase the incandescent lava in the crater is thrown into the air in large masses by great gas bubbles rising through the liquid, without material alteration of its temperature, but the magma of the depths, if our theory be true, is atomized, so to speak, into a gaseous emulsion whose temperature, although initially above that of the crater lava in the "Strombolian" phase, will be very quickly lowered by the enormous expansion—a degree of extension which can only be fully appreciated by one who, like the present writer, witnessed at close range the great emission of April 8th, 1906, whose volutes of vapor, even at the height of two kilometers, still expanded with an incredible acceleration in all directions. No witness of that great, continuing, trepanning blast could ever be persuaded that there remained in the throat of the volcano any broken solid materials whose trituration should furnish the ash of that and the following days, according to the ordinary conception.

We must accept the absorption of heat by gaseous expansion as the cause of a lower temperature or else admit for the depths of the volcanic conduit and the magmatic pocket or fissure a temperature inferior to that of some intermediate zone, as is often the case with geysers. The "Vulcanian" phase needs study.

Considering this principle of direct ash production as it may obtain in the phenomena of volcanoes of different types, it would seem that the highly viscous lavas of andesitic and trachytic nature might explode subaërially, upon sudden relief of pressure, into gas and divided solid material, causing such effects as the "Nuées Ardentes" of Mt. Pelée. At the other extreme, the ultrabasic Kilauea shows ash strata several meters in depth and ash fields many kilometers in extent, and there seems no reason to doubt that a sufficiently rapid outflow at a low level will cause even the Hawaiian subjacent lavas to froth up and be ejected as ash.

In this connection it may be noted that Dana,[3] writing of the thread-lace scoriæ of Kilauea, suggests that a further subdivision or frothing of the material might produce ash, and claimed for such a process an explanation of ash formation more reasonable than the trituration of rocks. Taking this with the many comments on the identity of ash and co-eval lava, it would seem that only a dynamic theory was required for the rounding out of a complete hypothesis. May not this conception of a subdivisional, intermolecular gaseous development and expansion in subjacent magma, upon relief of pressure from above, be accepted as a plausible explanation of the observed facts?

Naples, July, 1912.

Fig. 6.—The Main Lava Stream of the 1910 Eruption of Mount Etna.

Fig. 7.—The Gas Content of the Magma Caused the Explosive Projection of Incandescent Liquid Masses.

[1] "Some Conditions Affecting Volcanic Eruptions." *Science*, August 28th, 1908.

[2] "The Eruption of Vesuvius in 1872." L. Palmieri (page 119.)

[3] "Characteristics of Volcanoes." (Page 166.)

Selective Reflection in Ultra-violet Light*

Some Curious Cases

By Gustave Michaud

Prof. Woods of Johns Hopkins University has found that some white flowers, when photographed in ultra-violet light, appeared black or nearly so. This fact led the writer to examine the behavior, in such circumstances, of a number of alkaloids, glucosids and other vegetable immediate principles he happened to have on hand. The result is shown on the two accompanying figures. Fig. 1 was taken with an ordinary objective. Fig. 2 is a photograph of the very same substances taken with a quartz convex meniscus, silvered on both faces and completely opaque to visible light. The 24 substances had been previously powdered and somewhat compressed into their respective boxes. As the ordinary photograph shows, they were, with but one exception (berberin) perfectly white. Fig. 2 shows that, if our eye were sensitive to ultra-violet light, about two thirds of these white substances, when immerged in such lights, would appear to us as black or dark gray.

As a rule inorganic compounds do not seem to behave in such an extraordinary manner. Excepting zinc oxide which, as Prof. Wood has shown, powerfully absorbs ultra-violet light, and bismuth sub-nitrate which, as the writer and Prof. Tristan have found, reflects but little more ultra-violet light than zinc oxide, most inorganic compounds reflect ultra-violet light about as they reflect ordinary light.

The writer was unable to find any constant relation between the chemical constitution or physical properties of the 24 substances and their selective reflection for ultra-violet light.

The very marked differences shown on the two photographs will probably one day find some application to analytical chemistry.

[A somewhat different application of ultra-violet light to chemical analysis is reported in *Cosmos*. Marc Landau has been carrying on a series of experiments, which shows that for example a mixture of C_2H_4, C_2H_6 and H_2 can be analyzed by causing first of all the polymerization of the unsaturated hydro-carbon C_2H_4 through the agency of ultra-violet light. After this very slow reaction is completed the diminution in volume is measured, and oxygen is added. The gas mixture is then again submitted to photo-combustion, which, it is stated, converts the hydro-carbon into carbon dioxide and water.—Editor.]

* Reproduced from *Science*.

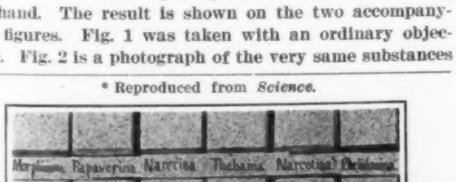


Fig. 1.—A Number of Alkaloids Photographed by Ordinary Light.

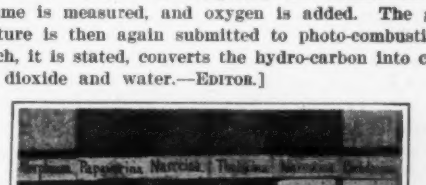


Fig. 2.—The Same Substances Photographed by Ultra-violet Light.

Controlling the Mississippi River*

Why the Levee System is Superior to All Other Proposed Methods

By Col. C. McD. Townsend†

When such a disaster occurs as swept over the Mississippi Valley recently, it arouses the intellectual activity of our people, and many suggestions are made of the means of preventing it.

As president of the Mississippi River Commission I have received numerous communications, attempting to explain the causes of this great flood, or giving the writer's views of the mistakes which have been made by the Mississippi River Commission in handling it.

The Mississippi River Commission has explained with great detail in its reports its reasons for relying on levees for protecting the country from overflow, but they appear to be unknown, not only to the country at large, but to many who reside in the Mississippi Valley and are most vitally interested in the problem.

I, therefore, consider it proper to appear before you and state briefly reasons for rejecting the various methods of flood control, other than levees, which have been suggested. As a full discussion of any one of the propositions would prolong my remarks to such an extent as to tax your patience, I can only touch upon the subject, and I have confined myself to stating not what I consider the most logical argument for the engineer, but the reason most evident to the general public for rejecting a proposition.

FORESTS AND FLOODS.

Judging from my correspondence, it would appear that there exists in the public mind an impression that the prime cause of floods in this country has been the destruction of the forests, and that the surest way to prevent them is by reforestation.

The subject of the influence of forests on stream flow is not unknown to the river engineer. It has been extensively discussed both by European and American engineers since Gustav Wex, imperial and ministerial counsellor and engineer of the improvement of the Danube River at Vienna, in 1872, submitted a series of papers on the decrease of water in springs, creeks and rivers, which were translated into English by the late Gen. Weitzel of the corps of engineers.

There is a great diversity of opinion on the subject, some maintaining that the cutting off of forests will ultimately convert Europe into a Numidian desert, while others claim that a moderate cutting of the forests even increases the rainfall. Whatever may be the theoretical principles involved, their practical application to the lower Mississippi River is fraught with great difficulty.

When a country acquires a population of nearly 100,000,000 people the forest primeval which existed when it was first settled has to disappear. It is all very well to bemoan the fact that if the black walnut, which once covered the State of Ohio had not been destroyed, and was sold as lumber at the present market rates, it would equal the assessed valuation of the property of the State; but there now have been created the cities of Cleveland and Cincinnati, whose people cannot live on black walnuts alone, but require grain and meat. The black walnut of Ohio has gone, never to return, and it is the same in other sections.

The fertile lands will not be taken away from the farmer. They are too valuable for raising potatoes and hogs. Only the poorer soils can be used for forest culture, and only a limited reforestation then is possible. It is, therefore, ridiculous to expect any better results in reference to floods from reforestation than existed before the forests were destroyed.

While our official gage records do not, in general, extend back much more than 40 years, yet on several of the Western rivers we have records of the heights of floods extending over a century. Thus at St. Louis there is a flood recorded in 1844, having a height of 41 feet on the gage. The next highest flood, in 1785, was over 40 feet. At Cincinnati, in 1832, there was one of 64 feet. It is needless to explain to this audience that a flood of such heights in either the Ohio or upper Mississippi would mean ruin to the plantations below Cairo if there were no levees to protect them.

It is, however, argued by some that with reforestation, if the floods occasionally were high they would not be as frequent. Again let us search the records of the past. It is hopeless by reforestation to expect to reproduce the forest growth that existed at the close of the Civil War. Yet from 1857 to 1867 there was a most remarkable series of great floods, occurring as frequently as any that have been recorded since that time.

* From a paper read at the Interstate Levee Congress at Memphis, Tenn.

† Corps of Engineers, U. S. A., U. S. Engineers' Office, Detroit, Mich.

RESERVOIRS FOR RIVER CONTROL.

Next to reforestation, reservoirs as a means of controlling floods appear to have the most advocates. The reservoir theory is particularly attractive, as we have before us in the great lakes a practical illustration of flood restraint, by means of natural reservoirs. Reservoir control of the Mississippi River was discussed by Humphrey and Abbot in 1858, and on the upper Mississippi the corps of engineers has constructed the largest system of reservoirs for regulating rivers that has been built in any country, having nearly twice the capacity of those proposed by the Pittsburgh flood commission for controlling floods at Pittsburgh. These reservoirs have been most successful, not only for increasing the low water discharge of the Mississippi River above St. Paul, the purpose for which they were constructed, but also for reducing floods in that portion of the river.

There is, therefore, nothing novel to the river engineer in the proposition to control rivers by reservoirs. We have not only studied its advantages, but we know its limitations. Conditions are extremely favorable for reservoir construction at the headwaters of the Mississippi, but while they materially increase the low water discharge at St. Paul and markedly reduce flood heights, yet 100 miles farther down the river it is impossible to detect their influence during either high or low water.

A reservoir must be close to the locality to be benefited, or its value rapidly diminishes, and this is a serious trouble with any project for regulating the lower Mississippi by reservoirs.

The material which is eroded from our hills is carried down by our rivers and deposited during floods on the lowlands of the lower reaches, making them the richest agricultural portions of our country. They become highly cultivated, buildings and fences are constructed, towns spring up and are connected by highways and railroads. Railroad wrecking is a rather popular amusement at present, so I omit their relocation from the discussion, but the engineer had better beware of that horny-handed son of toil, the American farmer. He is not going to consent to be driven from the rich alluvial valley to the less fertile hills, and is going to protest most vigorously against structures which will cover his fields with water from 150 to 200 feet deep. As he has votes, it is going to be necessary to listen to him, and the dams must be moved back to mountain streams where land is of little value. This renders necessary the construction of the reservoirs to control the Ohio River on the upper branches of the Allegheny, Monongahela and other tributaries, over 1,000 miles from its mouth. Those on the upper Mississippi will also be about 1,000 miles from Cairo, and those on the Missouri over 2,000. These are too great distances for the proper regulation of any stream.

Moreover, such a project leaves too large a proportion of the watershed unprotected to be effective. In fact, the flood of 1912 was caused by rains in that portion of the valley which would be without reservoirs. It was not the melting snow at the sources, but rains in midstream areas that created the damage. Neither at Cincinnati, St. Louis, Chattanooga or Nashville were flood heights excessive.

THE PITTSBURGH FLOOD PREVENTION PLAN.

I have recently been appointed a member of a board to investigate the use of reservoirs to protect the city of Pittsburgh from overflow. The Pittsburgh Flood Commission has a carefully prepared project which proposes to store in 17 reservoirs 59,000,000,000 cubic feet of water at an estimated cost of about \$21,000,000, which I consider very reasonable. Fifty-nine thousand million is a pretty large looking figure, but I made a little computation to see what it meant when translated into a unit applicable to the Mississippi River, and found that during less than seven hours 59,000,000,000 cubic feet of water flowed by the latitude of Red River at the crest of the recent flood, and, based on the estimate of the flood commission, it would, therefore, require over \$73,000,000 to build reservoirs that would hold the water that passed down the river in one day. The cost of storing one day's flow is ample for all the levee construction required on the river, while if reliance is placed on reservoirs, provision must also be made for the other 48 days the river was above a bank-full stage.

THE "CUTOFF" PLAN FOR REDUCING FLOOD HEIGHTS.

Another favorite method suggested for reducing flood heights is by means of cutoffs. The Mississippi River Commission in numerous reports has called attention to the injury which would result from cutoffs, the increased caving which is caused thereby, and the damage to navigation during low water.

These may be thought by some theoretical considerations. I desire to invite attention to the fact that cutoffs have been repeatedly tried in Europe as a means of reducing floods, but always with disastrous results. The most noted example is the river Theiss in Hungary.

This river originally had a very gentle slope, about equal to that of the Illinois River below La Salle. It was leveed with the same results which always obtain when rivers are confined—the height of its floods increased. It was then proposed to shorten the river by cutting off the bends, and thus giving it a deeper slope. The project was carried out, but the first great flood that occurred after the work was completed, rushed through the improved section much faster than the lower part of the river could carry it off. Flood heights were lowered, to be sure, at the upper end, but correspondingly increased at the lower, and in 1879 the town of Szegedin was destroyed by the flood.

At the Canal de Miribel on the Rhine a similar method was tried, with similar results. At the upper end of the reach both the high-water and low-water planes were lowered, with great damage to the low-water navigation, while at the lower end they were raised, producing increased flood heights and also injury to the low-water channel. A cutoff affords relief at one locality, but at the expense of another.

OPENING ADDITIONAL OUTLETS.

Outlets have been suggested as another means of relief, and the Mississippi River Commission has frequently discussed the inadvisability of outlets and waste weirs as a means of lowering flood heights. I differ with some of my conferees on this subject, but rather in the line of argument than in results. Where the river has depths exceeding 100 feet, as in the vicinity of New Orleans, I am of the opinion we could afford to permit a moderate diminution of river depths if thereby we could obtain a material reduction of levee heights. I also believe that the effect of outlets in reducing flood heights is not as great as is popularly supposed. The last flood, however, clearly demonstrated that wherever there was a large crevasse, which is but another name for an outlet, the river ceased to rise. Such outlets were not entirely satisfactory to the planter whose land was behind them. And another lesson to be derived from this flood is that if you are going to reduce flood heights by this means, you must also control your outlet, i. e., it will require a levee system of the same height as that of the main river, and the amount that is saved in the height of the levee line will not compensate for the extra length it is necessary to construct and maintain.

Another serious objection to an outlet is the difficulty in regulating the velocity with which the water will flow through it at varying heights of the main stream. If it is so constructed that it will discharge at a greater velocity than the river itself, there is danger of its enlargement to such an extent as to divert the greater part of the flow down it, and transfer the main stream itself into an outlet, and if, on the other hand, it discharges at a lower velocity, it will tend to fill with sediment.

DO LEVEES RAISE THE LEVEL OF THE RIVER BED?

There is considerable confusion in the public mind in reference to the effect of levees on the river bed, some believing that they cause the bed to scour out, while others are equally as positive that they cause the river bed to rise.

The motion of sediment in a silt-bearing stream is not clearly understood, even by many engineers who write on river hydraulics.

In such a stream there are certain sections called pools, which are usually found in the bends. These are separated by shallower sections which are called bars.

When the river is low the velocity with which the water flows through the pools is less than that with which it flows over the bars, and there is a tendency for the channel over the bars to scour out and the material eroded to be deposited in the pool below. As a river rises the velocity in the pools increases more rapidly than on the bars, and a period soon occurs when there is a greater scour in the pools than on the bars, so that the bars begin to rise and the pools to deepen. When the river falls the velocities in the pools decrease more rapidly than on the bars, and there is a reversal of the process—the bars deepening and the pools filling up. This action is modified by a movement of sand waves down the river, and by a centrifugal force which results from the piling up of water in the bends, but it occurs in all alluvial streams which flow with sufficient velocity to scour their beds, whether they are leveed or not. Levees may, to a certain extent, intensify this action, but they will not materially change it.

With such constant mutations the only way to determine whether the river bed is rising or being scoured out is by comparing corresponding low waters with each other, or corresponding high waters.

Several hundred years ago a French traveler visited Italy, and on his return reported that levees had raised the bed of the Po River. His statement was carefully investigated and found to be untrue, but like Wex's assertion that the cutting of forests has injured river beds, it has traveled over the whole world where rivers have been improved, and vexed the engineer in charge of their improvement.

The French engineers have made careful investigations of the leveed rivers of France, and found no evidence of such action; the Germans have studied the Rhine, and the Austrians the rivers of Austro-Hungary, and failed to detect it. The Mississippi River Commission has made similar observations of the Mississippi River, and found more evidences of a scour than of a fill. In no case has it been observed that the effect of levees to raise the river bed was more than a few tenths of a foot in a hundred years, and may be termed a geological effect resulting from the lengthening of the river as it deposits its silt at its mouth.

The assertion is now admitted to be false on the main rivers of all civilized countries which are capable of being studied, but it is still claimed that it is true in China and Japan. I recently visited Japan and had an opportunity to further investigate the subject. On the larger rivers, like the Osaka, there were no evidences of any such action, but in mountain streams which flow down steep hillsides and suddenly change their slope when they pass through plains, as is the case with a number of streams which empty into Lake Biwa, the upper portions of the streams have been scoured out, forming deep gulleys, and the material thus eroded deposited at the foot of the hills. The same conditions exist on the mountain streams which empty into the Mississippi that are not leveed, but the eroded material has an opportunity to spread over a greater area at the foot of the hills and is, therefore, not as perceptible.

My own view of the effect of levees on stream flow is that they tend to remove irregularities and make the slope more uniform. If a cutoff should occur, disturbing the river's regimen, they would tend to cause the river to return more quickly to its normal slope, raising those bars which had been unduly lowered, and scouring out those which were abnormally high. They should also, to a certain extent, enlarge the river section, but at a rate so low that it would be a question of practical importance to those who will inhabit the valley in the 25th century, rather than those who are tilling it to-day.

THE NECESSARY HEIGHT OF LEVEES.

While there is no evidence that the bed of the Mississippi River has risen from levee construction, it is apparent that flood heights have greatly increased in the last twenty years.

When the Mississippi River Commission was formed there existed two schools of engineers—one believed if the river were leveed it would scour out so that a large increase in flood heights would not occur, the other that there would be little enlargement of the river section, and that flood heights should be computed without regard thereto.

There was considerable discussion of those propositions, both by the commission and the general public, and the general public was very strongly opposed to the theory that high levees were necessary.

I take the liberty of recalling that about twenty years ago I submitted a paper to prove that if the St. Francis basin were leveed a flood like that of 1882 would attain a height at Helena of at least 54 feet. I was forthwith charged with being an enemy of the levee system. A state of the public mind existed similar to that which arose in Louisiana at the commencement of the recent flood, when I intimated there was danger to the levees of that State. I do not recall that any demands were made for my removal, but it was suggested to the commission that investigations by subordinate officers be discouraged.

Under these conditions it was necessary for the commission to establish a grade line for levee construction, and they announced a provisional grade, which was neither as low as many persons considered ample, nor as high as others thought necessary. This grade was generally accepted as a line to build to, the ultimate grade to which levees were to be constructed to be afterward determined by observation.

This was a most happy solution of the problem, as was forcibly demonstrated during the last flood, during which less than 1 per cent of the length of the levee line was destroyed. The engineer must always bear in mind that he must make the best use that is possible of the funds with which he is entrusted. If the ultimate grade line which this flood shows is necessary had been adopted, it is true that many miles of levee would have been held with comparatively little effort, as was the case in the upper Yazoo district, but to attain such a result the funds which would have been expended in constructing them, would have been taken from the remainder of the levee line which would have been necessarily weakened thereby, and crevasses would, therefore, have been much more frequent.

In fact, if it could be predicted that the next great flood would be similar to the last, even a somewhat lower provisional grade line would be desirable in certain portions of the river, as 586 miles of levees have not been constructed to this grade, and some 53,000,000 cubic yards must be placed in them to create the cross-section which has been adopted by the commission. But no two floods are similar. The grade line established by this flood will be subject to material changes arising from variations in the discharge of the White, Arkansas and Red rivers, or even from local rains.

ALL COMPLETED LEVEES HELD IN THE FLOOD OF 1912.

It will surprise many to learn that at none of the stations did the flood of 1912 reach a height equal to that of the provisional grade line, nor did a crevasse occur in any levee that was built to the grade and given the cross-section established by the commission, except possibly at Hymelia.

If the recommendations of the commission, made some fifteen years ago, had been carried out, this disaster to a great extent, would have been averted.

I do not mean to imply by this statement that the provisional grade adopted by the commission is the ultimate grade to which levees should be constructed. In fact, they must ultimately be built at least from 2 to 3 feet higher; but that if the provisonal grade and cross-section had existed throughout the valley, wherever the flood attained a height greater than the provisional grade, there would have been a good fighting chance to hold the levees by topping, while with defective foundations and weak section, the battle was lost before the river could attain that height.

As a result of this flood the commission does not recommend any immediate change in its provisonal grade; on the contrary, it is of the opinion that the first work to be done is to strengthen the foundations wherever any weakness has been observed, then to bring the section to standard dimensions. When the levee line is uniformly perfected to the provisional grade, its further enlargement will be advisable. Excessive strength in one locality, with the necessary undue weakness at others, should be avoided.

PROTECTION OF CAVING BANKS.

While about 2,500,000 cubic yards of the levee line was destroyed by crevasses during the last flood, over 4,300,000 cubic yards had to be abandoned during the past year on account of caving banks. The loss from crevasses is considered a national calamity, while that from caving banks is scarcely noticed. But I desire to particularly invite attention to the drain upon the community this caving of levees into the river has become. It requires an expenditure of nearly $1,000,000 annually to replace them. The Mississippi River Commission appreciates the relief that Congress has afforded them by its proviso that $4,000,000 of the $6,000,000 appropriated by the last rivers and harbors bill must be expended on levees. It precludes the use of any funds for the protection of city parks or even city fronts. But there is a danger from too close a limitation of the powers of the commission. It frequently is cheaper to construct a bank revetment than to rebuild a levee which is caving into the river. I apprehend that under the present act several hundred thousand dollars will be wasted. Because of its limitations levees must be made where bank revetments are more desirable.

FOUNDATIONS FOR LEVEES.

The advice which the commission has received on the use of concrete, steel piles, triple lap sheet piling, and other patent innovations for levee construction, would fill a large volume. I will not detain you with a discussion of these devices further than to state that we are convinced from the results of the late flood that greater care must be exercised in securing the levee foundations, but whether this result will be attained by an enlarged muck ditch, a wall of concrete or sheet piling, or other means, is dependent so much on local conditions, that no general plan can at present be formulated.

CONCLUSION.

The flood of 1912 affords no argument for the abandonment of levee construction. It has simply attained the height which Gen. Comstock and Maj. Starling predicted the flood of 1882 would have attained if the river had then been confined. It has cleared the atmosphere of certain false theories, and we can now resume operations with a definite knowledge of the problem before us. We are passing through the same experience European nations have had. Levees have been tested for ages, and have proved uniformly successful when built of adequate dimensions. During the progress of construction there were disasters on foreign rivers as well as in the United States. No other method of relief from floods has been successfully applied to large streams.

Originality is a very desirable quality in an engineer, but there is danger of confusing originality and ignorance. When a proposition with which he is unfamiliar is presented to him it is his duty to follow the instructions placed at some railway crossing, to stop, look and listen. He should investigate what has been done in the past, and seek to discover if there is no precedent for his action.

It was said several thousand years ago that there is nothing new under the sun. The saying is true to-day. To adopt a project, even though popular, that has been tried, found wanting, and rejected by our forefathers, is not progress, but retrogression.

The Elevator Action of the Rudder

Arising out of the accident to Lieut. Parke, when he made his famous dive, is a problem concerning the interchange of rudder and elevator actions, which, although known to many, may be new to several of our readers. The matter is very lucidly discussed by Major Brocklehurst in *Flight*.

In order to explain it he has prepared a set of simple diagrams, the first of which shows the rudder put over to the pilot's left, in order to turn to the left by the rudder action alone. In the second diagram it is assumed that the increase in peripheral speed of the outer wing, accompanying the turn, causes the machine automatically to bank. The rudder is now tilted sideways, and there is a small vertical component of the air pressure on its face. In fine, the rudder has begun to be an elevator.

Let us now assume that the condition is exaggerated to the point at which the machine is banked to 45 degrees. The lateral and vertical components of the pressure are now equal, and the rudder plane is just as much an elevator as it is a rudder.

The consequence of the combined effect is to make the tail swing upward and outward, thus promoting a dive. It is, therefore, reasonable to suppose that the elevator itself will now be put up to check the dive, in which case, the elevator being likewise tilted at 45 degrees from its normal position, acts as much as a rudder as it does as an elevator. So, although it may neutralize the elevating effect of the rudder, it is only by the difference in their respective areas that it will be able to actually depress the tail. If the bank is less than 45 degrees, as it would be of course in practice, the disparity of its influence is less marked, but, in any case, it augments the ruddering effect and so tends to lock the machine in its spiral path, which, if the speed increases, will augment the natural bank until it may in fact approach to the value of 45 degrees. On a steep spiral path, it is by no means easy to say exactly how much the machine is really banked, but it would appear as if it may easily introduce conditions analogous to an excessive amount, so far as they influence the action of the tail in the manner above described.

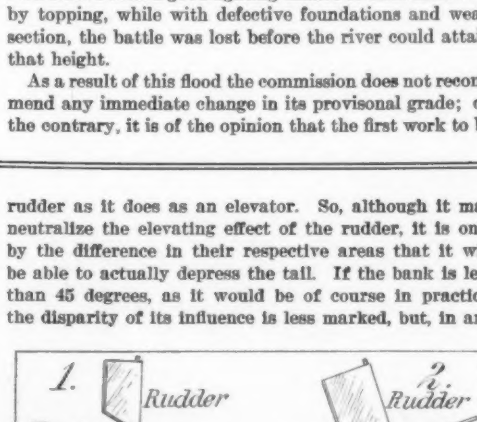


Diagram Illustrating Elevator Action of Rudder.

It is at any rate clear that the rudder must no longer be maintained in the positions shown in diagrams 1, 2, 3 (on this page) once the machine has assumed a high velocity downward. By throwing the rudder over to the pilot's right, i. e., ruddering outward from the spiral, both the ruddering and the elevating effects produced by the rudder plane are immediately reversed, that is to say, the rudder not only tends to straighten the flight path, but to reduce the steepness of the descent. This influence, although perhaps comparatively small in itself, is augmented by the action of the elevator proper, which is already in position for depressing the tail, it is not surprising, therefore, if an instantaneous flattening out of the machine follows this operation of the control. Any tendency to straighten the flight path likewise tends to obliterate the bank, which in turn tends to restore the elevator to the full exercise of its normal function.

Fig. 4.—Flexible Boiler Mallet Locomotive. The Boiler is Made in Two Sections United by an "Accordion" Joint.

Recent Development of the Locomotive*

The Latest Stages in Its Evolution

By George R. Henderson

SIZE AND POWER.

Ten or twelve years ago the steam locomotive had assumed such proportions that it was thought by many engineers that the limits of size and capacity had been practically reached. The increase in weight had been going on steadily for years, but with comparatively few advances that, at a single bound, were remarkably in excess of what had previously been done. About this time, however, a number of circumstances occurred which made it absolutely imperative that more powerful locomotives be obtained, and these last ten years have produced different reasons for increasing the power of the locomotive, treading fast one upon the other.

The advent of large-capacity freight cars has resulted in a train that could be more easily handled with a large tonnage than it could be in the old cars of less capacity, as the train length is shorter and the number of cars in the train considerably diminished for a given tonnage, which is a very important factor in connection with the proper operation of the brakes when descending grades. Instead of cars of 30 tons capacity, which were the common maximum a decade since, 50-ton cars are now very plentiful, and even cars of 75 or 80 ton's carrying capacity are being seriously considered. This means that for a train of the same number of cars double the tonnage can be hauled and a more powerful locomotive can be economically used.

The introduction of steel passenger equipment, with a view to eliminating many of the horrors of fire and collision, also calls for more powerful locomotives, as the weight of these cars has been very considerably increased. In olden times a 60-ton car was considered a very heavy vehicle, but nowadays 75 tons is not at all abnormal, and a weight of 90 tons has been reached.

The agitation for increase in wages of all men connected with the transportation department of railroads has been more or less generally successful, and in order to offset, to some extent, these increased expenditures, reduction in operating expense has been necessary. This is brought about very largely by the increased capacity of the locomotive. As an example of what can be done in this line, some years ago a road with which the writer was connected found, by the purchase of some passenger locomotives of considerably greater power than heretofore used, that each of these engines in the first year during which they were operated saved $5,000 in reducing the expense incidental to double-heading trains and running two sections, where the necessary cars could be handled by one of the new engines.

The increase in traffic due to the natural increase in population, which has for the United States amounted to 20 per cent in the last ten years, has in many cases called for either double-tracking, large additions for side tracks, or other provisions for handling an increased movement of tonnage over and above what could be arranged with the old facilities. With an increase in the power of the engine it is possible not only to handle tonnage more cheaply, but to handle a larger amount without any additional efforts in the way of dispatching or interference with other trains; for instance, if we could double the train load, we could practically move twice the amount of tonnage without increasing the number of meet orders or delaying trains in the opposite direction. On this account alone the large locomotive has been invaluable in enabling the companies to increase very greatly their tonnage without having to make large expenditures for improvement in tracking facilities, greater number of sidings, extra track, etc., and this has been no small part of the burden removed, although we do not hear as much said about this part of the operating problem as some of the others which we have mentioned.

The more recent decision of the Interstate Commerce Commission that the railroads should economize instead of increasing their rates calls for an additional effort in this line, and these cumulative experiences, coming closely one upon the other, within the past decade have brought about a locomotive of size and power which was not even dreamed of ten years ago.

The electric locomotive has made its appearance and has done very good work in certain localities, and in order to compete with such an engine, which has the output of a large stationary power-house behind it, the steam locomotive has had to increase its capability for exerting power. For years the clearance or height and width possible for locomotives, owing to the outlines of tunnels, heights of bridges, proximity of station platforms, buildings, etc., has prevented any considerable increase in these two directions, so that the remaining dimension, viz., that of length, was the one direction in which increases could be made. This has brought about, naturally, engines of long-wheel base with long boilers, and, while a few years ago tubes of 16 feet length were considered as quite long enough for good design, we now find them extended to as much as 25 feet, and the end is probably not yet. Of course, these increases in size mean increase in weight, which, while it is a natural consequence of the increase in power, is also necessary to provide sufficient adhesion to make use of this increase in power. This, however, means necessity for heavier track and bridges, and, in order to reduce the load on track and bridges as much as possible, the extension of this weight into increased length has helped to keep down the weight per lineal foot. This however, is increasing, as, while a few years ago 25 tons was thought to be a very large weight on one pair of drivers, 30 tons is now very frequently considered, and is, in fact, already exceeded in a few cases.

The question of longer boilers and longer engines leads us to a good many complications which have heretofore been avoided. While boiler flues have been used up to 25 feet in length, this is about the limit at which the mills are able to roll them, and besides, it is considered wise not to increase the lengths too greatly without having experience of gradual extensions. The new lengths of locomotives in many cases require, for structural reasons, if nothing else, a barrel as great as 53 feet, and, in order to fill up this space, there have been various means adopted to supplement the length of the flues. Combustion chambers extending from the fire-box forward, a distance of 5 or 6 feet, have been introduced, and the amount of boiler has been utilized for feed-water heaters, reheaters, superheaters, and other devices, all of which tend toward economical operation and make good use of the extra length of boiler shell. These different devices will be referred to more in detail later on, but the reasons for their existence and for having space to apply them, which we did not have some years ago, should be considered at the present time.

The lengthening of the boiler and the engine means that flexible wheel bases must be introduced. The favorite type of long, rigid wheel base engine has generally been the consolidation, consisting of one pair of truck wheels and four pairs of driving wheels; to this, later on, a trailing truck was added, giving us the 2-8-2, or Mikado type of engine. There were several reasons for the introduction of this type; probably the first one was to provide an engine which could be backed around curves and switches as easily as run forward. Consolidation engines have been in the past very largely used as helper locomotives, and, after helping a train up a mountain for ten or twenty miles, it was often desirable to back them down hill to be ready for the next ascent. If the road was crooked, derailments were likely to occur when having only a driving wheel to negotiate curves. The trailing truck, therefore, was originally introduced to enable these engines to operate with equal satisfaction around sharp curves in either a forward or backward direction. The construction of boiler was kept very similar to the Consolidation engine; that is, the fire-box was above the rear drivers and the rear truck was purely for guiding purposes.

With the desire for additional heating surface requisite for maintaining higher speeds, it was found that advantage could be taken of the trailing truck to bring the fire-box entirely back of the drivers and thereby make it deeper, as the truck wheel was so much lower than the

Fig. 5.—Near View of the "Accordion Joint."

* Paper read before the Franklin Institute and published in its Journal.

Fig. 6.—Oil-burning Mallet Locomotive. In a Coal-burning Engine the Endurance of the Fireman is the Limiting Factor in Power Development. The Use of Oil Removes This Limitation.

drivers. This gave longer tubes and a better fire-box for the proper combustion of fuel, and the increase in fire-box volume and heating surface has been considered so essential that nowadays the Mikado engine is used for road service, principally on account of the large boiler capacity which can be obtained thereby.

In the same way that the Consolidation locomotive was developed into the Mikado type, the Pacific locomotive was the outcome of the ten-wheel engine. In the olden times the ten-wheel engine was built with a deep fire-box between the frames and between the middle and rear driving axles, but, with the increase in dimensions necessary for modern locomotives, this space was too much restricted and the fire-box was raised entirely above the rear drivers. For the low wheels in freight service this answered well enough, but when it came to passenger engines with wheels from 70 inches to 80 inches in diameter the boiler was raised very high and there was little depth of fire-box possible. The addition of the trailing truck to this type of engine, therefore, allowed a deep fire-box and also a wide one by extending the boiler backwards until the fire-box was entirely in the rear of the driving wheels. This is illustrated by Fig. 1.

The Pacific type of locomotive may also be, in a measure, considered the logical development of the Atlantic type of engine, which first made its appearance about fifteen years ago. The original engine of this wheel arrangement was constructed for the Atlantic Coast Line in 1895, and was simply a ten-wheel engine with the rear driver changed to a trailing wheel in order to give room for a deep and longer fire-box, which could not be obtained with the regular high driving axle at the rear. The particular object to be obtained in this case was an increase in steaming power to haul at greater speed heavy trains which were needed for carrying the passenger traffic at that time. This engine, it will be noted, was not provided with a trailing truck, but the trailing wheels were simply placed in pedestals and located at about the same place where the third pair of drivers would have been in a ten-wheel type of locomotive. In this case it was not a question of adhesion so much as the possibilities of sustained horse-power at high speeds, and, as the tractive force of a locomotive always diminishes as the speed increases, the maximum adhesion is never used, except in starting and at very slow speeds.

The Pacific type of locomotive has become particularly popular for high-speed freight and heavy passenger service, and might now almost be considered the standard type of passenger locomotive used in this country for heavy trains at high speeds. For steep grades the Mikado type of engine has been used very successfully in passenger service, particularly on the Union Pacific Railroad, by making the driving wheels sufficiently large for the purpose intended and keeping the fire-box over the rear truck, as shown by Fig. 2.

It has been a general axiom in locomotive construction that the diameter of the driving wheels in inches should be as great as the maximum speed in miles per hour at which the engine is intended to run, this resulting in a speed rotation of 336 revolutions per minute when the speed above mentioned is attained.

In 1903 the Santa Fe type of engine, which is a 2-10-2 locomotive, was introduced, and which was really a Mikado engine with an extra pair of drivers inserted in the rigid wheel base. While it is the practice in this country to use flanged tires on all the drivers of Consolidation locomotives and those having a less number of driving wheels, yet when it came to the five pairs of drivers the flange was omitted from the middle wheel. It had been the custom to use bald tires on Consolidation locomotives, but experience later demonstrated that by placing the tires of the front and back wheels closer together than the middle wheels the tire wear was more uniformly distributed over the different wheels and there was no difficulty in passing curves of fairly sharp radius. At the present time a locomotive of the 2-10-2 type with 30-inch by 32-inch cylinders is being built, reviving the Santa Fe type of nine years ago. These latter engines will be used on the Chicago, Burlington and Quincy.

It seems, however, as if this were the greatest aggregation of driving wheels that could be used in a rigid wheel base, and when it is desired to use more than ten driving wheels it is necessary to go into the Articulated type of locomotive. The particular style most used in this country at the present time is termed the "Mallet," as it was originally proposed by M. A. Mallet, of Paris. In this device there are four cylinders, each pair operating a set of driving wheels in individual frames, the two sets being connected together by a hinged joint. This enables an engine with six, eight, or even ten pairs of driving wheels to pass curves with no more resistance than engines heretofore employed

There have been two ways of connecting the boiler to such engines and frames, the original method being to have the boiler with a rigid shell firmly attached to the rear engine and to allow the front, or low pressure section, to oscillate and slide transversely under the front end of the boiler, connection being made by means of flexible steam pipes (see Fig. 3). Sometimes, however, the overhang of the boiler is too great on sharp curves, and then recourse is had to the flexible boiler, or one with the "accordion" joint, as it is called. In this case both sections of the boiler are secured rigidly to their respective frames, but the accordion joint allows the boiler to bend when passing curves. This is illustrated by Figs. 4 and 5, the latter showing an enlarged view of the joint in the boiler.

In both these types of Mallet locomotives the rear wheels are operated by high-pressure cylinders receiving steam direct from the boiler, and this steam, after passing the high-pressure cylinders, goes through an intermediate receiver into the low-pressure cylinders, and finally to the exhaust. The various heaters of which we have above spoken are utilized in some cases, first, to superheat the steam before passing to the high-pressure cylinders, and secondly, to reheat the steam in its passage from the high to the low-pressure cylinders. The feed-water heater at the front end has been used to abstract heat from the gases during their last passage in the boiler so as to increase the temperature of the water and bring it practically up to a boiling point (at boiler pressure) before being delivered into the boiler proper. These various combinations of heaters and compound cylinders, of course, very considerably reduce the fuel consumption, which is an extremely important factor, now that the boilers have assumed such enormous size. It has been found by experience that an ordinary fireman cannot, as a regular performance, put in the fire-box more than from five to six thousand pounds of coal an hour, and, while for a short period some good men can exceed this rate, yet, ordinarily, it is unwise to expect him to handle more than this amount of fuel. The compound principle generally effects an economy of about 20 per cent, and as superheaters, reheaters, feed-water heaters, etc., may give as much more, it is plain that these devices have enabled us to get more power out of a locomotive fired by a single fireman than would be possible with ordinary simple expansion engines without the devices referred to.

The limit of physical endurance to the fireman has recently been recognized as the actual limiting factor in the development of power by a large locomotive, as it is found that locomotives with increasing size do not develop ordinarily horse-power in proportion to that size. Repeated tests of locomotives on testing plants and also in actual service indicate that one horse-power can ordinarily be obtained by from two or three square feet of heating surface, the former value being susceptible of attainment with compound locomotives and those equipped with a special economical device, while the latter figure applies to the ordinary saturated locomotive without the devices above mentioned. Under ordinary conditions the saturated steam locomotive will develop a horse-power with about four to five pounds of coal per hour, and for 1,000 horse-power there would be very nearly as much coal required as could be placed by an ordinary fireman. With compound engines, superheaters, etc., of course, the capacity of the fireman in horse-power can be very considerably increased, as above noted, but it is a fact that even locomotives with 5,000 or 6,000 square feet of heating surface often deliver only about 1,200 or 1,500 horse-power. This limitation of the steaming capacity, due to the human element of the fireman, has brought about the investigation and introduction of mechanical stokers, of which more will be said anon, but it is here mentioned in order to account for the extreme sizes of locomotives that have been proposed, as well as some actually under construction. Of course, the same limitations do not apply to locomotives which burn oil, as there is no difficulty in getting sufficient oil in the fire-box for practically any reasonable rate of combustion, and some of the largest engines heretofore built have been arranged to burn liquid fuel. This is notably true of the southwestern part of this country, where the oil fields in Texas and California furnish a fuel that, in addition to overcoming the limits of physical endurance of the fireman, also enables steam to be generated at a cost considerably below that for coal. This is illustrated by the Southern Pacific locomotive in Fig. 6.

Following these lines of increase, locomotives of more than two sections have been proposed in some cases in which the successive engines have received the steam in sequence, so as to form in effect a triple-expansion engine, and in other cases in which the steam has an expansive ratio of 2 obtained by exhausting from one pair of cylinders into two others. In order to keep down the length of the engine within reasonable limits, the tender can be made to do its share of the work, and, without increasing the length and only slightly the weight and expense, a locomotive can be constructed having about 50 per cent more hauling capacity than a heavy Mallet type of locomotive as now in use.

The Mallet locomotive is no experiment, as many hundreds of them are in use in this country, but the triplex Mallets are still a problem for speculation and production. The first compound locomotive built by the Baldwin Locomotive Works was constructed in 1889, and, while the compound type of locomotive for a few years after this was very strenuously sought on account of its fuel economy, it was found that there were other objections which, in many cases, overcame the benefits of reduced fuel consumption. With the introduction of the Mallet locomotive, however, the compound feature is of great importance, first, as it reduces the amount of fuel needed to produce a given amount of power, thereby enabling a large locomotive to be successfully handled by an ordinary fireman, and, secondly, that the pressure of steam passing through the flexible joints is only about one third of the boiler pressure, thereby reducing the difficulty of keeping these joints tight. When this type of engine was first placed in service it was feared that these ball joints would cause considerable difficulty, and, while some trouble has been found, this is being largely overcome as the round-house men become more familiar with the engines and expert in the packing of these joints.

There has been a type of locomotive introduced by the Borsig Company of Germany in which there are flexible wheels, these being mounted on tubular shafts through which the driving axle passes, so that, while the axles themselves are held in rigid boxes and operated from one pair of cylinders, the wheels can slide and swivel to adjust themselves to different degrees of curvature. We understand that these engines have given good service in certain localities in Europe, but we do not think that any of them have been introduced into this country.

To be continued.

Spontaneous Heating of Stored Coal

Its Cause and Prevention

Owing to the many requests for exact information on the deterioration and spontaneous heating of coal, the Bureau of Mines has published a preliminary paper by Horace C. Porter and F. K. Ovitz, giving a summary of the results thus far obtained. An abstract of this paper is here reproduced from *Power*.

A study was made of the loss of volatile matter from crushed coal during storage. The coal tested was in 20-pound samples and represented a variety of kinds from widely separated fields. Each sample was broken to about half-inch size at the mine, placed as quickly as possible in a large glass bottle and shipped to the laboratory. At the laboratory the accumulated gas was withdrawn and the volatile products were permitted to escape freely and continuously at atmospheric pressure and temperature. The results of these experiments have been published in a technical paper of the Bureau of Mines, and will not be given here in detail. Suffice it to say that, although several coals evolve methane in large volumes, especially shortly after mining, the coals tested lost in one year from this cause only 0.16 per cent at most of their calorific value. It seems, therefore, that the loss caused by escape of volatile matter from coal has been greatly overestimated.

At the instance of the Navy Department more elaborate tests were undertaken to determine the total loss possible in high-grade coal by weathering. The extent of the saving to be accomplished by water submergence as compared with open-air storage was to be settled, as was also the question whether salt water possessed any peculiar advantage or disadvantage over fresh water for this purpose.

OUTLINE OF TESTS.

In brief, the tests by the bureau were carried out as follows: Four kinds of coal were chosen, New River, W. Va., on account of its large use by the Navy; Pocahontas, Va., from its wide use as a steaming and coking coal in the Eastern States, and the principal fuel used in the Panama Canal work; Pittsburgh coal, as a rich coking and gas coal, and Sheridan, Wyo., sub-bituminous coal or "black lignite," as a type much used in the West.

In the tests with the New River coal, 50-pound portions were made up out of one large lot, which had been crushed to quarter-inch size and well mixed, and portions, confined in perforated wooden boxes, were submerged under sea water at three navy yards that differed widely from one another in climatic conditions. Portions of 300 pounds each from the same original lot were exposed to the open air, both outdoors and indoors, at the same navy yards.

The Pocahontas coal was tested at only one point, the Isthmus of Panama, where run-of-mine coal was placed in a 120-ton pile exposed to the weather. Pittsburgh coal was stored as run-of-mine at Ann Arbor, Mich., both in open 5-ton bins outdoors and in 300-pound barrels submerged in fresh water. The Wyoming sub-bituminous coal was stored at Sheridan, Wyo., both as run-of-mine and slack, in outdoor bins that held 3 to 6 tons each.

Duplicate samples were taken at each sampling, and the sampling of every lot, except the outdoor pile at Panama and the 300-pound open-air piles at the navy yards, was done by rehandling all the coal. In the excepted cases it was not thought fair to disturb the entire lot. Therefore at Panama a vertical section of the pile, weighing 10 tons, was removed each time; eight gross samples were taken from this 10-ton portion, and each of the samples was quartered down. From the outdoor piles at the navy yards a number of small portions were taken from well distributed points in each pile, mixed, and quartered down. Small lots, finely divided, were purposely chosen with the New River coal, to make the tests most severe.

A fact the authors emphasize is that physical deterioration of the coal was not tested, such as increase of friability, or slacking of lumps. Consequently the results do not show how the relative availability of heat units may have been affected by physical changes; but they do show how much the calorific value, as determined in the laboratory, was affected by storage of the coal under the several conditions.

RESULTS OF TESTS.

The accompanying table is a condensed summary of results from a large number of tests and determinations. The moisture, ash, and sulphur contents and the calorific value of each sample were determined. To eliminate the effect of incidental impurities that were not concerned in the deterioration of the actual coal substance, the calorific values are calculated to moisture, ash, and sulphur free bases, and the ash as determined is corrected for errors due to oxidation of pyrites and dehydration of shale or clay.

The New River coal showed less than 1 per cent loss of calorific value in one year by weathering in the open. In two years the greatest loss was at Key West, 1.85 per cent. Practically nothing was lost by the submerged samples in one year, fresh or salt water serving equally well to "preserve the virtues" of the coal. There was almost no slacking of lumps in the run-of-mine samples. In all tests the crushed coal deteriorated more rapidly than the run-of-mine.

The Pocahontas run-of-mine coal in a 120-ton pile on the Isthmus of Panama lost during one year's outdoor weathering less than 0.4 per cent of its heating value, and showed little slacking of lumps.

Gas coal during one year's outdoor exposure suffered practically no loss of calorific value, measurable by the calorimetric method used, not even in the coal forming the top 6-inch layer in the bins.

The Wyoming coal in one of the bins deteriorated in heat value 5.3 per cent during storage for two and three fourths years, and more than 2.5 per cent in the first three months. There was bad slacking and crumbling of the lumps on the surface of the piles, but even where this surface was fully exposed to the weather the slacking did not penetrate more than 12 to 18 inches in the 2¾-year period.

No outdoor weathering tests of coal of the Illinois kind have been made by the Bureau of Mines, but tests of such coal have been reported by Prof. S. W. Parr, of the University of Illinois, and by A. Bement of Chicago, both of whom find a calorific loss of 1 to 3 per cent in a year by weathering. Bement reports a slacking of lumps over 80 per cent in one test and of about 12 per cent in another test of small samples. Possibly with the Illinois as with the Wyoming coal, the slacking in a large pile would not penetrate far from the surface.

Storage under water unquestionably preserves the heating value and the physical strength of coal, but such storage practically makes necessary the firing of wet coal, and consequently the evaporation in the furnace of added moisture varying in amount from 1 to 15 per cent according to the kind of coal. This is an important drawback to underwater storage of coals like the Illinois and Wyoming, which mechanically retain 5 to 15 per cent of water after draining. High-grade Eastern coals, however, are ordinarily wet down before firing; hence, the 2 or 3 per cent of moisture these coals absorb during storage becomes of little consequence. Submerged storage absolutely prevents spontaneous combustion, and that alone may justify it when the coal is particularly dangerous to store and when large quantities are to be stored; but unless the coal is to be stored longer than one year, storing under water merely to save calorific value by avoiding weathering seems unjustified.

SPONTANEOUS COMBUSTION.

Losses of value from spontaneous heating are much more serious than the deterioration of coal at ordinary temperatures. Oxidation proceeds more rapidly as the temperature rises. Beginning at ordinary temperatures, attacking surfaces of particles, and developing heat, it is probably, in some degree, an absorption of oxygen by the unsaturated chemical compounds in the coal substance. In a small coal pile this slowly developed heat can be readily dissipated by convection and radiation and very little rise in temperature results. If the dissipation of the heat is restricted, however, as in a large pile densely packed, the temperature within the pile rises continuously. The rate of oxidation plotted against the temperature makes a curve that rises very rapidly. When the storage conditions allow warming of the coal to about 212 deg. Fahr., the rate of oxidation becomes so great that the heat developed in a given time ordinarily exceeds the heat dissipated, and the temperature rises until, if the air supply is adequate, the coal takes fire. Evidently, therefore, it is important to guard against even moderate heating of the coal, either spontaneous or from an external source. Increased loss of volatile matter and of heating value occurs with a moderate rise of temperature, even though the ignition point is not reached.

Spontaneous combustion is brought about by slow oxidation in an air supply sufficient to support oxidation, but insufficient to carry away all the heat formed. The area of surface exposed to oxidation by a given mass of any one coal determines largely the amount of oxidation that takes place in the mass; it depends on the size of the particles and increases rapidly as the fineness approaches that of dust. Dust is, therefore, dangerous, particularly if mixed with lump coal of such size that the interstices permit the flow of a moderate amount of air to the interior. Coals differ widely in friability, that is, in the proportion of dust produced under like conditions. In comparative tests samples of Pocahontas, New River and Cambria County, Pa., coals produced nearly twice as much dust (coal through a ⅛-inch screen) as coal mined from the Pittsburgh bed in Allegheny County, Pa. This variation in friability affects the tendency to spontaneous heating.

Ideal conditions for such heating are offered by a mixture of lump and fine coal, such as run-of-mine with a large percentage of dust, in piles where a small supply of air reaches the interior.

EFFECT OF VOLATILE MATTER.

High volatile matter does not of itself increase the tendency to spontaneous heating. A letter of inquiry sent by the bureau to more than 2,000 large coal consumers in the United States brought 1,200 replies. Of these 260 reported instances of spontaneous combustion and 220 of the 260 gave the name of the coal. The 220 instances were distributed as follows: Ninety-five were in semi-bituminous low-volatile coals of the Appalachian region, 70 in higher-volatile coals of the same region, and 55 in Western and Middle Western coals. This shows at least no falling behind of the "smokeless" type of coal in furnishing instances of spontaneous combustion, and no cause for placing special confidence in this class of coal for safety in storage.

The high-volatile coals of the West are usually very subject to spontaneous heating, but owe it to the chemical nature of their constituents rather than to the amount of volatile matter they contain. Strange as it may seem, the oxygen content of coal appears to bear a direct rela-

CALORIFIC VALUE (IN GRAMME CALORIES) OF THE COAL SUBSTANCE (MOISTURE, ASH AND SULPHUR FREE COAL) BEFORE AND AFTER STORAGE.

Kind of Coal.	Storage Conditions.	Place.	Calorific Value.				
			As Stored.	After 3 Months.	After 1 Year.	After 2 Years.	Percentage of Loss in 2 Years.
New River, W. Va. *a*	¼-inch coal, under sea sea water.	Portsmouth, N. H.	8761	....	8759	8730	*b* 0.39
		Norfolk, Va.	8754	....	8763	8737	*b* 0.40
		Key West, Fla.	8747	....	8732	8770	0.00
	¼-inch coal, under fresh water.	Pittsburgh, Pa.	8752	8762	8749	8760	0.00
	¼-inch coal, exposed to air indoors.	Portsmouth, N. H.	8779	8738	8742	8709	0.80
		Norfolk, Va.	8751	8742	8736	8717	0.39
		Key West, Fla.	8754	8728	8676	....	....
		Pittsburgh, Pa.	8769	8736	8719	8720	0.56
	Run-of-mine coal, exposed to air indoors.	Portsmouth, N. H.	8754	8758	8748	8734	0.23
		Norfolk, Va.	8743	8764	8725	8725	0.21
		Key West, Fla.	8745	8733	8710	....	....
		Pittsburgh, Pa.	8753	8758	8740	8743	0.11
	¼-inch coal, exposed to air outdoors, uncovered.	Portsmouth, N. H.	8741	8730	8701	8674	0.77
		Norfolk, Va.	8726	8709	8666	8625	1.16
		Key West, Fla.	8739	8721	8680	8592	1.85
		Pittsburgh, Pa.	8763	8726	8700	8665	1.12
	Run-of-mine coal, exposed to air outdoors, uncovered.	Portsmouth, N. H.	8775	8766	8760	8722	0.60
		Norfolk, Va.	8743	8745	8720	8695	0.55
		Key West, Fla.	8752	8708	8722	8632	1.29
		Pittsburgh, Pa.	8752	8740	8716	8696	0.64
Pocahontas, Va.	120-ton pile, run-of-mine coal, outdoors.	Panama	8794	8787	8762	....	....
Pittsburgh bed	4 tons run-of-mine coal, in open bin, outdoors.	Ann Arbor, Mich.	8541	*c* 8539	8526	....	....
			8541	*d* 8553	8528	....	....
Sheridan, Wyo., sub-bituminous. *e*	Run-of-mine, open bin, 5 feet deep.	Sheridan, Wyo.	7370	7174	....	7135	*f* 3.19
	Run-of-mine, closed bin 5 feet deep.	Sheridan, Wyo.	7370	7202	....	7094	*f* 3.75
	Run-of-mine, closed bin 15 feet deep.	Sheridan, Wyo.	7370	7303	....	6982	*f* 5.26
	Slack, closed bin 15 feet deep.	Sheridan, Wyo.	7355	7166	....	6990	*f* 4.96

a Heating value of representative mine samples of coal (ash, moisture and sulphur free), 8,768 calories. *b* On basis of original heating value of same test portion. *c* After six months' storage, entire lot in bin. *d* After six months' storage, upper 6 inches at surface of bin. *e* Each bin contained 5 to 10 tons. *f* After two years and three quarters.

tion to the avidity with which coal absorbs oxygen; high-oxygen coals absorb readily, and, therefore, have a decidedly marked tendency to spontaneous combustion.

EFFECT OF MOISTURE AND OF SULPHUR.

The effects of moisture and sulphur on spontaneous heating have been much discussed with wide difference of opinion. Little experimental evidence has been brought to bear on either question, and neither is yet settled. Richters has shown that in the laboratory dry coal oxidizes more rapidly than moist; but most practical users of coal believe that moisture promotes spontaneous heating. In none of the many cases of spontaneous combustion observed by the authors could it be proved that mositure had been a factor. Still the physical effects of moisture on fine coal, such as closer packing together of dust or small pieces may often aid spontaneous heating.

In certain laboratory experiments, where air was passed over samples of coal heated to 248 deg. Fahr., enough heat developed to almost ignite the coal; the coal was then allowed to cool. Subsequent analysis showed practically no increase in the sulphate, or oxidized form of sulphur, and practically no reduction of the total sulphur in the coal. Though the results of these experiments are not entirely conclusive, they indicate that sulphur content contributes very little to the spontaneous heating of coal.

IMPORTANCE OF FRESHLY EXPOSED SURFACES.

Freshly mined coal and the fresh surfaces exposed by crushing lumps exhibit marked avidity for oxygen, but after a time the surfaces become oxidized, "seasoned," as it were, retarding further action of the air. In practice, coal that has been stored for six or eight weeks and has even become already somewhat heated, if rehandled and thoroughly cooled by the air, seldom heats spontaneously again.

SUGGESTIONS IN STORING COAL.

With full appreciation that any or all of the following suggested precautions may prove impracticable or unreasonably expensive under certain conditions, they are offered as advisable for safety in storing bituminous coal.

1. Do not pile over 12 feet deep, nor so that any point in the interior of a pile will be over 10 feet from an air-cooled surface.
2. If possible, store only screened lump coal.
3. Keep out dust as much as possible; to this end reduce handling to a minimum.
4. Pile so that the lump and fine are distributed as evenly as possible; not, as is often done, allowing lumps to roll down from the peak and form air passages at the bottom of the pile.
5. Rehandle and screen after two months, if practicable.
6. Do not store near external sources of heat, even though the heat transmitted be moderate.
7. Allow six weeks' "seasoning" after mining and before storing.
8. Avoid alternate wetting and drying.
9. Avoid admitting air to the interior of a pile through interstices around foreign objects, such as timbers or irregular brickwork, or through porous bottoms, such as coarse cinders.
10. Do not try to ventilate by pipes, or more harm may often be done than good.

Charles Lathrop Pack

President of the National Conservation Congress

There was peculiar fitness in the selection of Charles Lathrop Pack as President of the National Conservation Congress. Mr. Pack is of the rare type of active and busy man of affairs who finds time for public usefulness along broad and comprehensive lines. His interest in his work, whether business or civic, has always been constructive and practical, and this quality has been the essence of the success with which his efforts have been attended. It is a logical assumption that his administration of the affairs of the Conference will be attended by the same energy and ability that have been so satisfactorily applied in other directions.

Mr. Pack formerly lived and is still vitally intereste in Cleveland, Ohio. In that city he has for years been a dominant factor in business and in public affairs. As President of the Cleveland Chamber of Commerce he was a leader in the small and active group of men whose work was vitally effective in the development of a greater and better Cleveland. As a trustee of Western Reserve University of Cleveland he has played an important part in educational development. In this work, as in business affairs, one of his close associates has been Dr. H. A. Garfield, now president of Williams College.

Although a lumberman by instinct and business and since boyhood an owner of standing pine, Mr. Pack has by no means confined himself to one line of activity. He has been successful in other branches of the business field. In Cleveland and elsewhere he is recognized as exerting a strong influence in financial affairs. The Cleveland Trust Company, one of the Forest City's most important institutions, owes much of its growth to his effort. He was one of the Company's organizers and is a member of its Board. He is also a director of the Seaboard National Bank of New York City.

Mr. Pack is well known as an authority in economic forestry matters. He was one of the first Americans to study forestry in Germany. After his return from Germany, he explored in the pine regions of Canada and in the South.

His interest in sound money led him years ago to take a prominent part in the sound money movement, and he was the youngest member of the Indianapolis National Monetary Commission.

When the first conference of the governors of all the States took place at the White House, during Mr. Roosevelt's administration, Mr. Pack was invited by the President as one of the experts on the subject of Conservation. Later, the President made him one of the National Conservation Commissioners. With Mr. Gifford Pinchot, his close friend, Dr. Eliot of Harvard College and a few others, he organized the National Conservation Association.

Mr. Pack is a life member and a director of the American Forestry Association, and he has been very active in the movement that has during the past two years widened the field of work of the association and increased its usefulness. He has delivered addresses on Forest Conservation and Taxation before the American Civic Association and other bodies. His work for Conservation is widely and well known, and he has been closely allied with the Conservation movement from the first. His interest is constructive and economic rather than political, and he has refused more than one attractive political office.

Evidence of the breadth of his vision and the wideness of his scope of usefulness is afforded by the fact that Mr. Pack is not only interested in the conservation of material resources, but also in those things that make for more equal opportunity, and for the conservation of human life. His unique gift to one of the New England colleges for the purpose of providing an annual sum for the improvement of the quality of the milk, butter and bread consumed by students is an example of the practical turn of his mind in that direction.

Charles Lathrop Pack.

Mr. Pack was for seven years an active member of the Cleveland City Troop, later called Troop A, of Ohio. He retains as a veteran member his connection with that crack organization, which holds the record for efficiency among the cavalry organizations of the National guard.

As a young boy, he lived in the pine woods of Michigan, where he was born May 7th, 1857. He grew to manhood in Cleveland. The Packs had emigrated from England, and in Colonial days were a New Jersey family. A few years ago Mr. Pack returned to that State, making his home at Lakewood. He is a member of New Jersey Forest Park Commission.

At the recent meeting of the National Conservation Congress at Indianapolis, Mr. Pack was elected president of the Conservation Congress for the next year—a signal honor richly deserved because of his training, his prominence in the Conservation movement and his long-continued and consistent service. He has been a prominent figure at former Congresses, and is keenly alive to their usefulness, principles and possibilities. The Fifth American Conservation Congress is to be congratulated upon its choice of a president. He will undoubtedly do much to increase the usefulness of the organization and to broaden the field of its endeavor.

The Effect of Preliminary Heat Treatment Upon the Drying of Clays

A series of experiments has been carried out by A. V. Bleininger of the Bureau of Standards, for the purpose of looking into the possibility of using the excessive plastic clays, which on drying by any commercial method show great losses due to cracking and checking, by subjecting them in the crude state to a preliminary heat treatment before working them by the usual methods. There are, especially in a number of the Western States and on public lands, many clays of this sticky, heavy type which resist all ordinary modes of preparation. To this class of materials belong the joint and swamp clays of the glacial regions of Ohio, Indiana, Illinois, Wisconsin, Minnesota, North Dakota, and other States and Territories.

The author summaries the results of his investigation (published in No. 1 of the series of "Technologic Papers") as follows:

The plasticity of clays is decreased by heating at temperatures above 100 deg. Cent. This change becomes more marked with higher temperatures and is accompanied by reduction of the drying shrinkage upon reworking. According to the nature of the clay, the change proceeds abruptly after reaching a certain temperature or is more or less gradual throughout. A decided alteration seems to occur in most clays between 200 and 300 deg. Cent., as is shown by the granular appearance of the clay and the decrease in the drying shrinkage. The color also becomes darker, and in ferruginous materials assumes a reddish hue.

The purer clays seem to be affected more gradually by this heat treatment.

The rate of drying of the preheated clays does not seem to differ from the rate for the undried clays.

Excessively plastic clays, which dry difficultly and result in loss due to checking and cracking, behave normally in drying after being preheated. The best temperature for this treatment must be determined for each clay, and invariably the lowest possible temperature giving the desired result should be adopted. Some preheated clays seem to release their soluble salts more easily then the normal materials. Such clays are likely to show dryer efflorescence.

PRELIMINARY HEAT TREATMENT OF CLAYS.

Clays thus treated should be tempered with as little water as possible and require good lubrication.

The cause of the improved drying quality of the preheated clays is to be sought in the increased porosity. It appears that coagulation of the flocculent portion and the fine, nongranular particles of the clay takes place, analogous to the set of certain gels.

The combined drying and burning shrinkage of preheated clays (burnt through vitrification) is less than that of the normal materials. In most cases the drying shrinkage is decreased at the expense of the burning shrinkage, which becomes greater than the normal contraction. In some clays the increased porosity in the dried state may cause the burning shrinkage (if carried through vitrification) to be excessive, in which case the product will show checking or cracking in burning. Such clays, unless their objectionable features in drying can be eliminated by preheating at a low temperature, are not benefited by this treatment.

Preheating offers a possible commercial method for the treatment of excessively plastic clays which cannot be worked and dried successfully by other means.

Rate of Multiplication of Organisms

Miss L. L. Woodruff has followed the successive generation of a single paramecium through a period of five years. In this time no less than 3,029 generations were produced and if these individuals had all been preserved their aggregate mass would be equal to ten thousand times that of the earth!

Experimental Tugboats

The "Fulton" and the "Froude"

[The SCIENTIFIC AMERICAN *has already presented to its readers the story of what has been accomplished by the "Froude" which for two or three years has been maintained in the Charles River Basin—between Boston and Cambridge—by the Massachusetts Institute of Technology, a boat that is really a laboratory in which every element in the propulsion of a vessel can be tested for itself. With the aid of a fund presented to the Institute by Mr. Clinton H. Crane and Mr. Arthur Curtis James a sister boat was built last winter in the Technology shops, the model being that of a towboat. It was put into the water in June and during the summer was used for experiments the results of which are here given.*—EDITOR.]

THERE are three ways of studying the question of propulsion of ships. The most conservative way is to make scientific trials of ships themselves and this is habitually done for warships. This method is difficult and expensive and an analysis showing the distribution of credit (or criticism) between the hull and the machinery is often illusive. Another method due to the Froudes, father and son, is the towing of models of ships (ten or twenty feet long) in experimental basins. These latter, with their corps of scientists, call for large sums for establishment and maintenance and are least satisfactory at the most vital point, namely the combination of hull and propeller. A third way is by the trials of miniature ships with their own machinery, and this is the method used by the Department of Naval Architecture and Marine Engineering of the Massachusetts Institute of Technology, under the direction of the head of the department, Prof. Cecil H. Peabody, with the assistance of members of the staff, Prof. Harold A. Everett and Messrs. H. H. W. Keith and R. B. Pulsifer.

This work has been going on for three years, first for two years on the "Froude" and now for the past summer on the "Fulton." The "Froude" is an exact model on a scale of one fifth of the revenue cutter "Manning," having a length of 38 feet and a displacement of 8 tons. The "Fulton" is one third size of the U. S. Navy tug "Sotoyoma" with a length of 31 feet and a displacement of 9.6 tons. The propelling machinery used first in the "Froude" and then in the "Fulton" is a special electric transmission which makes it possible to run with any propeller and to make exact scientific measurements.

The work of the past summer has been the investigation of tow-boats and towing, about which there was very little precise information. The method of the Institute is especially adapted for this purpose and there is now offered exact and simple information for the designer of tow-boats. A tugboat and especially a harbor tugboat of small size appears to be an insignificant affair and that is one reason why the original type has come down with little improvement. But all the tow-boats working along our seaboard, in our harbors and on the inland lakes and rivers betoken a very large and important industry.

The ocean-going tow-boat that can take a string of barges and a cargo of its own, is a small powerful steamship, which may have a length of 175 feet and a displacement of 1,100 tons. The "Sotoyoma" is a little shorter and fuller bodied than the "Manning," but of much the same type. She is a particularly well designed steel towboat of the harbor class with a length of 92.7 feet and a displacement of 260 tons.

In the "Fulton" and the "Froude" technology has therefore two little towboats, one of the harbor type and the other of the sea-going type. Whatever these boats do their prototype when driven at the corresponding speeds will do. With the special electric propulsion, all kinds of propellers may be driven with any degree of power and scientific relationships of energy consumed to speed and behavior may be accurately determined.

The advantage of steamboats for towing purposes were so obvious, that forms and proportions were settled early in the history of steam navigation. It is interesting to know that the first use proposed for steam in naval warfare, was the humble one of towing three-deckers into (or out of) action and old seamen required a good deal of convincing before they ventured to depend on the "new contraptions" for actual fighting.

The "Fulton" Leaving Its Shed.

Towboats were at first built of wood as all ships then were, and there are good reasons for keeping to that old material after most other ships, including Dutch canal boats, are made of steel. Wooden tugboats are still preferred by some well informed persons in important ports. The towboat engine was at first slow and simple because engineers could build no others; with a small, cheap crew the old, slow, non-condensing engine still has its advantages even if it is wasteful of fuel. The sea-going towboat is likely to have a first-class triple-expansion engine and competent crew.

When screw-propellers were first proposed they were naturally given wider blades with square corners; of such form are the propellers, now in the Smithsonian Institution, made by John Stevens about 1804. Conservatism has kept that type standard, although designers have at times broken away from it.

The various questions concerning towboats hinge on the propeller which must be made to fit the machinery, unless the machinery can be modified to fit the propeller. The little Tech. towboats the "Fulton" and the "Froude" have a variety of propellers, any of which can be driven at the proper power and speed and therefore it may be readily determined what conditions are necessary for best results.

There are two main elements that control the design and performance of propellers, the pitch-ratio and the area-ratio. The latter is easily defined because it is simply the ratio of the area of the blades to the area of a circle drawn through the tips of the blades. A four-bladed propeller may have an area-ratio as small as 0.36 or as large as 0.72.

The pitch of a screw is the distance from one turn of the thread to the next turn of the same thread. Machinery bolts have only one thread of which there are many turns; a propeller may have four threads (blades) each having about one eighth of a turn. The pitch-ratio is the ratio of the pitch of the blade to the diameter. To the casual observer, some attention is required to see that the propeller is really a screw, which may popularly though rather inaccurately be conceived as screwing its way through the water and driving the ship ahead of it. It is then easy to see that a small pitch-ratio would give only a small advance per turn and would require a high speed of turning, and that on the contrary a large pitch-ratio would need but a small speed of revolution. The slow engines preferred for towboats require a large pitch-ratio, something like 1.3 to 1.5; steamships have commonly a pitch ratio of unity (or nearly unity) and a ship which has a propeller with that ratio and a diameter of 20 feet would advance 20 feet for each turn of the shaft if the propeller really screwed its way through the water. Such a ship would, however, in practice be likely to go about 17 or 18 feet per turn.

The experiments made with the "Froude" in 1910 and 1911 were to investigate the somewhat intricate question of the interaction of the hull and the propeller. This question is of vital importance to the scientific designer of ships but need not be considered further here. While these investigations were under way there had been a good opportunity to make some experiments on towing as a side issue. The "Froude" had three propellers having pitch-ratios of 0.8, 1.1 and 1.5, respectively. When first made they all had large area-ratios (about 0.6), which was cut down successively to 0.5 and 0.45, the latter being fairly liberal since the ratio of 0.36 is very common for steamships. The effect of these experiments on towing showed conclusively that area-ratio, within the limits used in practice, has no effect whatever on towing. This conclusion has a wide scope and shows there is no reason why the traditional wide, square-cornered blade should be used for towboats; instead, the oval-shaped blade and a fairly liberal area-ratio like 0.5 will suffice for all conditions.

Having disposed of the matter of area-ratio, the "Fulton," which is a little harbor towboat of exceptionally good design, was provided with three propellers having the area-ratio of about 0.5, the pitch-ratios being 0.8, 1.00 and 1.3.

A towboat has three duties, first, to run free without a tow, when it usually throws a large wave and makes considerable fuss, because, while not really going very fast it is doing well for its size; next; (2) to tow at reduced speed (for example at half speed) using something like one eighth of its power for propelling itself and the rest for pulling its tow, and (3) to push a ship into its berth at a slow rate of speed.

Tests were made with both the "Froude" and the "Fulton" for all three of these conditions, running free, towing at 0.6 full speed and pushing. The tests with the "Fulton were the more complete, and included also the effect of towing with a long line and towing abreast.

The results of the experiments were:

Running Free.—The problem of designing a towboat when running free without a tow presents some difficulty and uncertainty because its speed is relatively high and like all boats under that condition a little increase in speed demands a large increase in power. This is probably the least important duty of a towboat excepting where competition is sharp and the first comer gets the tow. Even so it is not best to insist very much on speed, for it is a costly item.

The experiments on the "Froude" and the "Fulton" show that the exceptionally wide blade has a small but perceptible disadvantage; and on the other hand the slow-running propeller with a pitch-ratio of 1.3 to 1.5 has a small but definite advantage. Both these conclusions were expected because they are indicated by exhaustive experiments by Naval Constructor D. W. Taylor, U. S. N., at the model basin in Washington.

The law of comparisons allows the designer to base his designs directly on these experiments, because for the prototypes, the "Manning" and the "Sotoyoma"—well designed craft that may be copied to advantage—because for them there exist both trials of the full-sized ships and experiments with their models as well as the experiments mentioned here.

Towing at 0.6 Full Speed.—This is for most towboats the most important duty and that for which the design should be made with little if any sacrifice for getting

speed when running free. For towing, the technology experiments show exhaustively that there is no advantage from the use if wide blades and that, as already stated, a liberal area like 0.5 is all-sufficient.

There is a positive though not a large advantage from the use of a quick-running propeller for towing at half-speed. This advantage is not enough to force that type of propeller on the designer if he has preference for the slow engines. Perhaps the most important aspect of the question arises with the tendency to use gasolene or other internal combustion engines for towboats, because these experiments show that there is no disadvantage in towing with a quick-running propeller suitable for such an engine. When towboats with internal combustion engines can be handled with the certainty of the automobile in the crowded street, they will force their way against conservatism. They will do this because they have the great advantage that they burn fuel only when working. The usual steamboat must always have its steam up and fires ready.

It has been said that the design of a towboat to run free at full speed is uncertain because the speed is high for the size; on the contrary the speed in towing is moderate and there is now no difficulty in determining the power required for towing at a desired speed.

One of the oldest methods of estimating power for ships, so long as the speed is moderate for the size, is what is termed the Admiralty co-efficient method. In passing it may be said that the speeds of the most recent Atlantic liners when judged by this standard are not excessive because of their great length. If ships were all of the same type and had speeds corresponding to their lengths the Admiralty co-efficient would be constant. For usual types and moderate speeds the co-efficient varies from 250 to 300. The experiments of Prof. Peabody and his assistant show that the Admiralty co-efficient for a towboat, towing at about half speed, is about 22. The reason for such an exceptionally small value is that only a small fraction of the power is taken for driving the boat and the rest is required for pulling the tow.

Pulling and Pushing.—Where a long ship is forced into her berth at the dock two or three towboats may be seen at her bow or stern with their bows against her massive hull puffing away industriously. They are then pushing with all their force without making any appreciable headway. It is for this duty that wide blades and a good pitch have been considered necessary, but the experiments with the technology boats show that first a moderate width of blade is enough, and, second, that there is a very marked advantage in favor of the quick-running propeller. For example, if the slow propeller of the "Fulton" with a pitch-ratio of 1.3 be taken for the standard, then a medium speed propeller with 1.0 pitch-ratio can push 10 per cent harder, while a quick propeller with pitch-ratio of 0.8 can push 15 per cent harder. The consideration of ability to push can best be estimated by direct study of the experiments making proper allowance for size.

General Summary.—It may be concluded from these experiments that a towboat will run free slightly faster with a slow propeller; that for towing it makes little difference whether it is fast or slow; and, finally, that for pushing the quick propeller has considerable advantage. Probably the best all-round advantage comes from using a medium-speed propeller with a pitch nearly equal to the diameter, a proportion which has been found desirable for all kinds of ships.

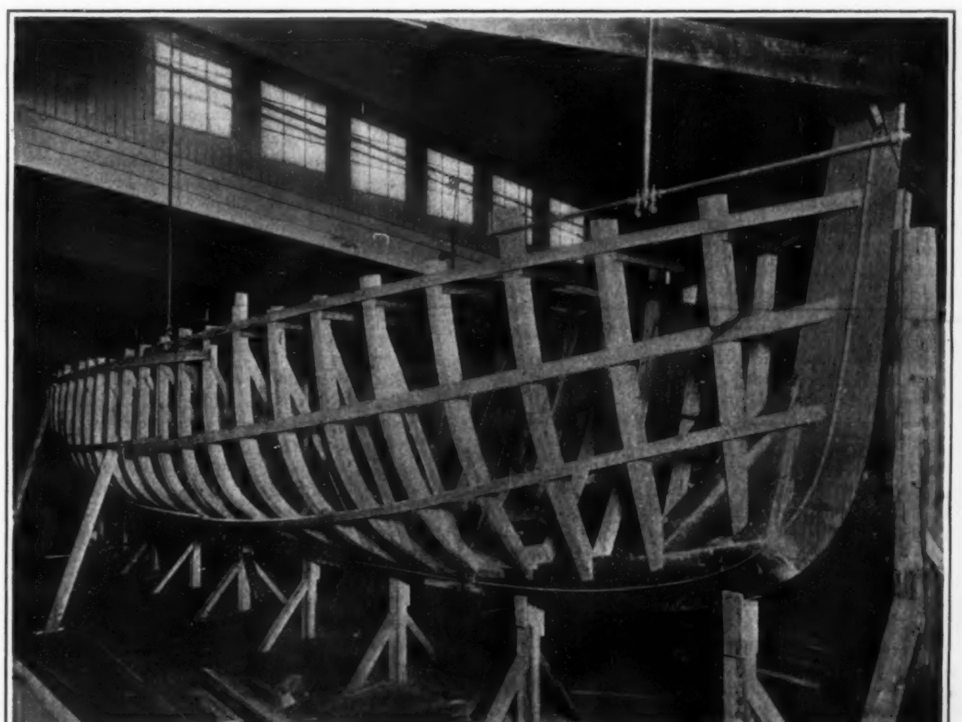
Further experiments were carried on with the two little boats of the technology navy for the determination of the effect of different lengths of tow-line. For convenience, the general tests were made with a line about twice the length of the boat and this gave scope enough to avoid influencing the action of the propeller. But even at that distance the tow was appreciably affected by the wash from the propeller. To investigate the effect of the length of line it was gradually lengthened to about six times the length of the towboat and with this increase in length of line there was a corresponding decrease in the drag on the tow-line, the gain being about 10 per cent.

In a seaway, ships and barges are towed with a long line; in smooth, restricted waters the towboat is commonly brought alongside. Experiments on the "Fulton" show that the gain from towing alongside over towing with a short line is about 10 per cent. It is, therefore, about equally advantageous to tow alongside or to tow with a long line, and a short line should be used only on occasion when necessary.

Despite a busy summer there remains other work in sight for the "Fulton," which can be done most advantageously with such a floating laboratory, sufficient to keep her busy one or two seasons longer. Only one full-power speed was chosen for the summer's work, namely at 0.6 full speed; but various speeds are found in practise and a series of experiments in towing at 0.2, 0.3, 0.4 and 0.5 speed and all at full powers would be very useful as indicating the most economical rate for various kinds of towing taking into consideration the various types of craft towed and the distance that there is to go.

A paper on the experiments of the "Fulton" and the "Froude" was presented by Prof. Peabody at the recent annual meeting of the Society of Naval Architects and Marine Engineers, which in general had a favorable reception with several corroborative incidents in the experience of the members of the society. Attention was called to the fact that the customs in towing are different in the different maritime regions and proper caution demands that deviation from current practice should be made only with caution and with due respect to the experience of those handling the towboats. On the other hand the difficulty of gaining guiding principles from the experience of men skilled in one line only, especially if not accustomed to careful observation, were brought out by several speakers. In one instance a certain company had available for each towboat two types of propeller and the captain was given his choice. The propeller of his choice was always reported as doing better, no matter which was the type preferred. Again a certain captain complained of a certain propeller and it was ordered changed. By mistake and without his knowledge the same propeller was replaced and he thereafter reported the boat to be doing much better. Captains often prefer wooden towboats and when one of steel was added to a certain fleet, it was severely criticised. Careful observation showed no disadvantage and on the contrary with a fair trial it did several per cent more work.

It must be remembered, however, that every piece of experimental work must stand on its own feet and is useful only so far as it is certain and complete. The application to practice of the results of experiments—so far as they may be practical—must lie in the hands of designers who are conversant with all the conditions of service.



Skeleton of Experimental Tugboat.

"Direct" versus "Continuous" Current

In a recent issue of the *General Electric Review* there is published a symposium, the expression of opinions by different persons, as to the most desirable terminology to be followed in speaking of the several types of current which occur in electrical engineering practice.

Dr. Charles P. Steinmetz states his views on this matter as given to the National Electric Light Association:

"The definition of the A.I.E.E. Standard Rules is: 'direct current' is a current which always flows in the same direction.' Such a current, therefore, may be constant in intensity, or may be pulsating, like that of a rectifier or some arc lighting machine. 'Continuous current' is a direct current of constant intensity; it, therefore, is distinguished from a pulsating direct current. The direct current commutating machine gives a continuous direct current, and therefore may, and usually is, called a continuous current machine, and the production of pulsating direct currents which, therefore, cannot be called continuous currents, is now limited only to rectifiers. Therefore, the name 'continuous current' has become practically universal, because practically all direct currents now are continuous currents."

Mr. H. H. Hobart, Consulting Engineer with the General Electric Company, favors the use of "continuous current." From the preface to his "Dictionary of Electrical Engineering," published in 1909, we quote:

"The old question of the relative merits of the terms 'continuous current' and 'direct current' is still unsettled. There is little to choose between the two terms; nevertheless it should be practicable definitely to adopt one or the other. The term 'continuous current' has been selected in the present work; and in addition to the support of such authorities as Prof. Sylvanus Thompson and Prof. Gisbert Kapp, there is the considerable advantage that it conforms with the terms employed in the French and Italian languages."

Turning to the definition of "continuous current" in this dictionary, we find the following:

"Continuous current (preferable abbreviation c.c.)—A continuous current is a current flowing in one direction only. The above is the preferable and also the most widely adopted definition of continuous current, and is in accordance with the decision of the I.E.C., who report as follows: 'Continuous current, an electric current in one direction and sensibly steady or free from pulsation. Abbreviated c.c. The term "direct current" is not recommended. Unfortunately in the 1907 Standardizing Rules of the A.I.E.E., the term direct current is adopted for expressing the above meaning, thus: "A direct current is a unidirectional current;" and this definition is followed by: "A continuous current is a steady or non-pulsating direct current."'"

Quoting from Mr. Hobart's dictionary again, we find under the entry "Direct current" the following:

"Direct current. See the preferable term, continuous current, the abbreviation of which is c.c."

It seems to us that Mr. Hobart is not very fortunate in presenting his plea. The decision of the I.E.C. which he quotes is not in full accord with Mr. Hobart's definition—for Mr. Hobart has omitted the clause "and sensibly steady or free from pulsation."

If we were to accept Mr. Hobart's definition, what term should we apply to a unidirectional pulsating current? Perhaps Mr. Hobart wishes to speak of it as a *unidirectional* current, but why not call it a *direct* current, as has been the custom of many heretofore? We are then at perfect liberty to speak of a continuous current as a direct current if we choose, just as we may call a horse an animal—the class includes the sub-class. It does not follow that we may speak of *any* direct current as "continuous;" this seems to us an undesirable usage.

The terminology thus proposed seems in every way satisfactory. Those who have been in the habit of speaking of the usual continuous type of direct current simply as "direct current" may continue to do so, and those who termed it "continuous current" may also adhere to their usual practice. Only such, if any, as have spoken of pulsating direct currents as "continuous," would be at variance with the terminology proposed.

Forest Products of the United States

The Economic Value of Our Trees

Two departments of the Federal Government have co-operated in the preparation of the elaborate table and map reproduced on the opposite page—the Census Bureau of the Department of Commerce and Labor, and the Forest Service of the Department of Agriculture. For anyone not conversant with the conditions of the American timber industry, who will have the patience to devote a few minutes' study to this combined exposition of what may at first sight seem dry facts, the result is likely to be a very interesting illustration of the country's natural wealth. Gold, silver and copper mines make a direct and captivating appeal to the imagination; but most of us are still new enough on American soil to think of our trees chiefly as impediments to agriculture and building, bequeathed by our savage predecessors, who knew not the riches to be derived by labor and skill from the soil under their feet, and valued them little, if at all, as in themselves constituting a crop spontaneously given to man by nature.

But besides this first impression of abundant natural wealth, there is condensed in these two exhibits a mass of interesting information both statistical and botanical. To be sure, the tabulation is extremely condensed, and the map—representing, as it does, a territory larger than any other continuous national territory except that of Russia—is of necessity interpreted by a diagrammatic scheme which may not be intelligible at the first glance.

By way of elucidation, then, it may be said here that the aim of the graphic schemes in both the general summary at the lower right-hand corner of the map and in each of the States (except Nebraska and Nevada) is to display synoptically the relative quantities of the various species of wood produced. This is done by means of carefully measured areas marked with numbers corresponding to those of the respective species in the table. Thus, yellow pine (marked 1 in the table) vastly predominates in the softwood output of the United States, forming only a little less than one-half of the whole; while, among the hardwoods, oak is about two-fifths. Applying the same scheme to the State of Michigan, for example, it is shown in a graphic way that there the softwoods and hardwoods (separated by a vertical line) are in nearly equal proportions, hemlock very largely predominating among the former, and maple among the latter. These approximate proportions may be checked by the table, where the outputs are given by millions of feet board measure: the quantity of cypress, for example, produced during the year 1909 in Arkansas, given as 55 in the table, was 55,000,000 feet board measure. In some instances the quantity of one particular kind of wood produced is too small in proportion to the whole output to be distinctly indicated in the graphic diagram for the State, and is therefore left out altogether.

The interest of this map and table is greatly enhanced by reference to the pamphlet, compiled under the direct supervision of W. M. Steuart, J. E. Whelchel, R. S. Kellogg (forest assistant) and A. H. Pierson, issued by the two Federal Departments already mentioned, and entitled "Forest Products of the United States." By the light of a few facts culled from this exhaustive report, which includes nine bulletins previously issued for the year 1909, the synoptical presentation becomes a picture of the natural forest growth of North America, seeing that very few species of trees are peculiar to the regions far north of the Canadian border. The money value of this product in 1909, "figured in round numbers for the principal items, including firewood and fence posts and other miscellaneous forms, amounts to approximately $1,250,000,000, or about 19 per cent more than the corresponding estimate of values for the products of 1908." As to the uses of the product, the pamphlet divides its subject into: Lumber, lath and shingles; cross-ties; pulp-wood; tanbark and tanning extract; slack and tight cooperage stock; veneers; poles, insulator pins, etc.; wood for distillation; turpentine and rosin. The first of these nine divisions includes a brief discussion of "minor species," which reveals one or two facts not very generally known, though the "minor species," as a class, are not of much commercial importance, their total value, for 1909, being only $2,109,794. More than half of this value, moreover, is in mahogany, a species which is imported, not grown in the United States. "The figures given for mahogany," says the report, "by no means represent the total importation of this valuable wood, since much of it is consumed in veneer and other establishments, reports of which are not included in this bulletin. Other woods in the table are used largely for special purposes, and not sawed into lumber to any extent. This is particularly true of locust, persimmon, and dogwood." Of course none of these minor species are included in the large table, where the quantities are given in millions of feet: only six of the twenty, including mahogany, reach an output of one million feet, while coffee wood, myrtle and mulberry (Iowa, Oregon and Arkansas respectively) are given at only 1,000 feet each. Such varieties of timber as cucumber (West Virginia and Virginia), silver bell (Virginia), bois d' arc (Oklahoma and Kansas) and laurel (California) will be novelties to most people. "Cucumber," we are told," is included with yellow poplar by some mills." It seems, too, that North Carolina produces shittim, a wood commonly associated with the Old Testament. The teak credited to Massachusetts in this table (40,000 feet, valued at $4,400) must be, like mahogany, a foreign species.

Coming back to the staple American species, it appears that the description of yellow pine, which, as the table shows us, covers nearly half of all the softwood produced in this country, extends to "all pine lumber reported which was produced east of the Rocky Mountains, with the exception of white, Norway, and jack pine. The term covers, therefore, several botanical species. . . . These species include those known commercially as the North Carolina and Virginia pines of the Carolinas and Virginia; the longleaf pine of the Gulf States; and the shortleaf pine of Missouri, Arkansas, and Texas." The center of yellow pine production moved westward during the period 1899 to 1909, the two leading states in the present table, Louisiana and Mississippi, having increased their production, the former to three and a half times what it was in 1899, the latter to twice what it was. In 1899 the cut of Georgia, though not much larger than what it was in 1909, was the largest reported.

The supply of the chief hardwood, oak, for lumber, lath and shingles, was actually less in 1909 than in 1899, though its value was 50 per cent greater. The leading place in this species now occupied by Tennessee was in 1899 held by Indiana. The highest value reported ($31.06 per thousand feet) is from Indiana; the lowest ($13.51), from Ohio. Among the interesting changes noted is that in the output of basswood in Wisconsin—24.7 per cent less in 1909 than in 1899. Wisconsin and Michigan together cut more than half of the total supply, the incomes to these two States from this source alone having been respectively $2,539,836 and $1,469,625. If the leading timber States were to be given trees as emblems—to each State a branch or twig of the tree which gives it its eminence in the production of timber—the distribution to fourteen of them would be: Arkansas, red gum; California, red wood; Indiana, sycamore; Louisiana, cypress (yellow pine being excluded on account of the vagueness of the term); Maine, spruce; Michigan, maple or beech; Minnesota, white pine; Montana, larch; Ohio, walnut; Tennessee, oak, Washington, Douglas fir; West Virginia, chestnut; Wisconsin, hemlock; Wyoming, lodgepole pine.

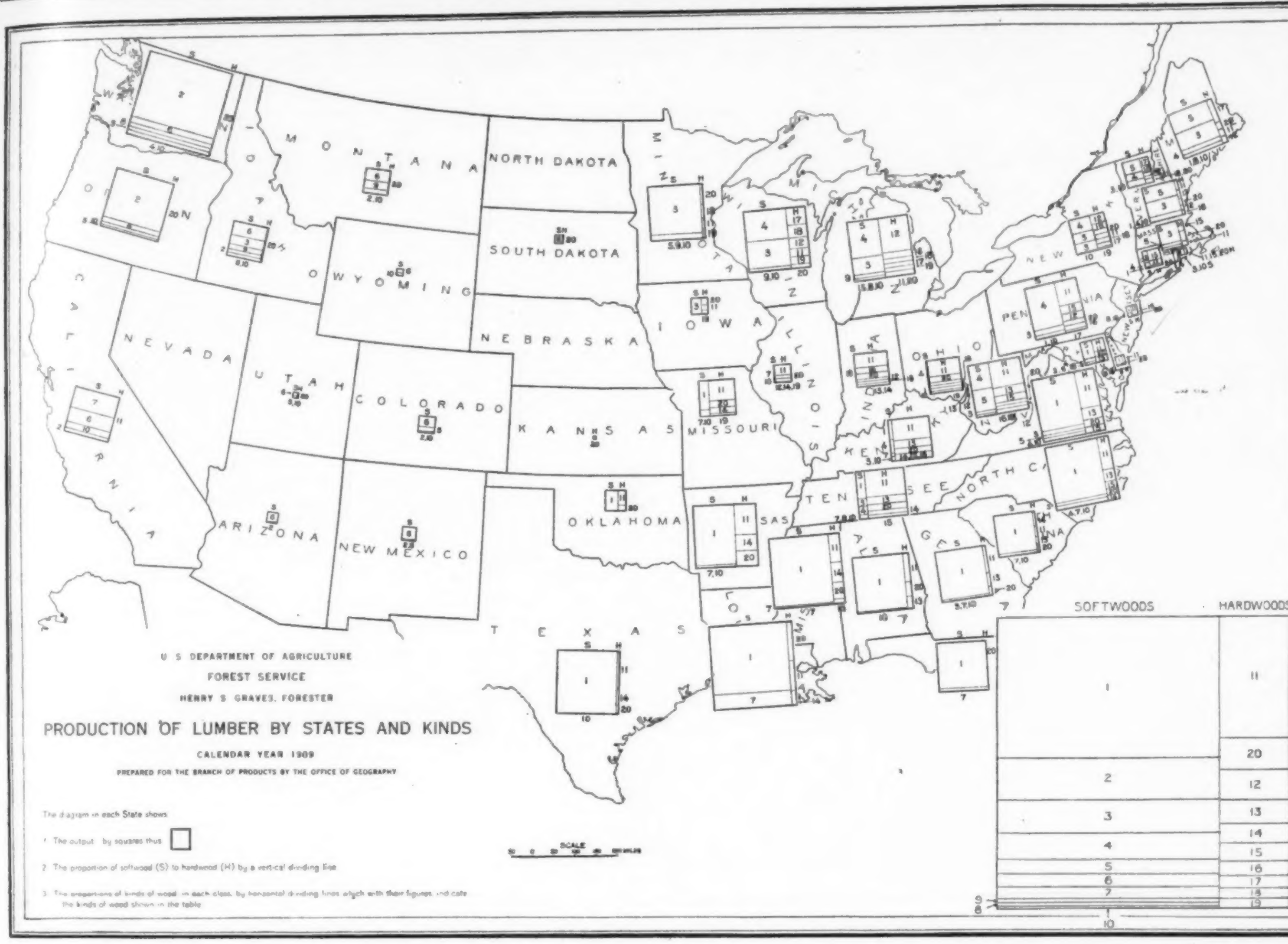
Passing on to the less obvious uses of timber, it is interesting to note that the quantity of wood used in the pulp industry was double, in 1909, what it was in 1900. Moreover, "the year 1909 was marked in the pulp industry, as in most other lines of industrial enterprise, by a resumption of the good business conditions which existed prior to 1908. The total consumption of pulp wood by the 253 mills reporting in 1909 was 4,001,607 cords, an increase of 645,654 cords, or 19.6 per cent, over the amount used by the 251 mills reporting in 1908, and of 38,947 cords, or 1 per cent, over the quantity reported in 1907, which year previously held the record." Of this large production (amounting in value to $34,477,540), which may be fairly connected with increased activity in the publishing business, 48.8 per cent—nearly one-half—was derived from domestic, 19.7 from imported spruce; so that 67.5 of all the wood-pulp paper made in this country in that year came from the spruce tree. At the same time, the report notes the decreasing use of spruce wood for this purpose and the increasing use of balsam, pine, and white fir. In former years, it seems, it had been the custom of the business, in New England, to allow a certain percentage of balsam pulp wood to be delivered as spruce; the change in reported percentage of spruce may to some extent be attributed to a greater strictness in insisting on separation of the species. White fir was reported separately in the pulp wood returns for the first time in 1909. It is said to be easily reducible by the sulphite process and to have a fiber about one half longer than that of the eastern spruce. It is said to be abundant in California and other Western States, forming 30 to 40 per cent of the stand in some of the California forests. "Previously there have been few uses for white fir," says the report, "and the demand has been slight. Its use for pulp will mean much for national forest management, increasing its value in timber sales." Cottonwood has been less used for this purpose, while the species of woods appearing to a small extent in this category include chestnut, maple, basswood, gum, birch, Douglas fir, tamarack, cedar, buckeye, also willow and cucumber.

Of all the pulp wood used in the country (4,001,607 cords), 23 per cent was used in the New York mills, which numbered 90; Maine came second, with a percentage of 22.6; Wisconsin, third, with a percentage of 14.4 of the total. These three, therefore, account for over one-half the total pulp wood used in the United States. It is curious that Massachusetts, reputed the most literary State in the Union, should convert less wood pulp into paper than any of the other thirteen States considered worthy of individual representation in this report. Another interesting point to be noticed is the decrease in the apparent average quantity of pulp obtained by all processes from a cord of wood. This is said to be due "in part to the increasing use of woods other than spruce, in part to the fact that a lower proportion of the total is reduced by the mechanical process, and in part probably to the relative condition of the air-dryness reported."

Among the materials used for tanning are three which did not appear separately in the bulletins for years previous to 1909: mangrove bark, chestnut wood, and myrobalan nuts. Of these the first and the last, being imported, do not properly concern the main subject of the pamphlet. The two principal indigenous barks used in this way are hemlock and oak. The oak used is of two kinds: Tanbark oak (*Quercus densiflora*) on the Pacific slope; chestnut oak (*Quercus prinus*) in other parts of the United States. Besides these substances themselves, extracts made from them are largely used, the total cost of extracts for 1909 being given as $10,779,177 as against $11,125,750 for the raw materials.

As an indication of the country's commerical activity, the statistics of timber in cooperage stock is of especial interest. This stock is classed as "slack" and "tight," the latter description applying to barrels, kegs, etc., intended to contain liquids. Of the "slack" stock in all forms (staves, headings and hoops) the aggregate value produced in 1909 was $20,195,125, representing an increase of $3,294,474 over the aggregate value for 1908. This increase in aggregate value was all the more noteworthy because the prices of such stock had decreased steadily since 1907. In "tight" cooperage only staves and headings are of wood, and here the increase of quantity over that of the 1908 output (approximately 34,000,000 and 176,000 sets of headings) was coincident with a decrease of aggregate value, the aggregate value for 1909 ($12,918,260) being $1,488,183 less than for 1908, and $6,889,110 less than for 1907. For staves and headings the five most largely used species were red gum, pine, beech, elm and maple; the least used of all the species separately enumerated was willow. Elm is the wood most largely used for hoops; cedar, the least. Oak comes eleventh in the classified list for slack cooperage staves and headings, but leads all other species in tight cooperage stock. The order of species used in the latter stock for 1909 is given as follows: white oak, red oak, pine, gum, ash, basswood. The total value of tight cooperage staves exported from the United States in 1909, as given by the Bureau of Statistics, was $5,524,199, against $6,016,690 in the preceding year and $4,673,085 in 1910—a steady decrease in the three years.

Under the heading of Veneers, the report says: "The veneer industry has shown steady and rapid growth in the past three years, the quantity of wood consumed by the 637 establishments which reported in 1909 being 435,981,000 feet, log scale, compared with 382,542,000 feet consumed by 402 establishments in 1908." The most marked increase has been in the quantity of red gum consumed, which, says the report, "indicates the lines along which the industry has been developing most rapidly, namely, in connection with the manufacture of packing boxes, baskets, and barrels, for the manufacture of which articles this wood is chiefly used, while the more moderate gains reported for kinds of wood like birch, maple, oak, and beech represented the growth in the manufacture of 'built-up' lumber, which is gradually taking the place of high-grade lumber for certain uses demanding strength or beauty of finish, such as doors, furniture, interior finish, and panels." The list of woods used for veneering contains 33 domestic species given by name, beginning with red gum, yellow pine, maple, cottonwood, and yellow poplar. But the veneering industry also uses considerable quantites of imported timber, the largest importations being of mahogany, and the smallest (of the species reported separately) ebony, of which 1,000 feet, log scale, was used in 1909. The value of the domestic woods was nevertheless, in that year, about three times that of the imported. There are 24 different thicknesses in which veneer is sawed or sliced, the thickest being five-sixteenths of an inch; the thinnest one-hundred-and-tenth of an inch; but 37 per cent of the stock produced by sawing or slicing is one twentieth of an inch



Map of the United States, Showing Graphically the Distribution of Forest Products by States. The Numbers on the Rectangular Areas Correspond to Those at the Head of the Columns in the Annexed Table.

PRODUCTION OF LUMBER—BY STATES AND PRINCIPAL KINDS
DURING THE CALENDAR YEAR 1909
(Millions of feet board measure)

States.	Softwoods.											Hardwoods.											Grand total soft-woods and hard-woods.
	1. Yellow pine.	2. Douglas fir.	3. White pine.	4. Hemlock.	5. Spruce.	6. Western yellow pine.	7. Cypress or red wood.	8. Cedar.	9. Larch or tamarack.	10. All other.	Total.	11. Oak.	12. Maple.	13. Yellow poplar.	14. Red gum.	15. Chestnut.	16. Beech.	17. Birch.	18. Basswood.	19. Elm.	20. All other.	Total.	
Alabama	1,507						* 6	* 3			1,516	87	* 1	88	* 17	* 2	* 1		* 1	* 1	27	175	1,691
Arizona		6				57					63												63
Arkansas	1,314						55				1,369	359	* 19	* 4	201				* 1	* 18	145	742	2,111
California		89			* 18	365	322	* 15		137	1,141	2										2	1,143
Colorado		6			22	95				9	142												142
Connecticut	2		31	11							44	34	* 4			78	* 1	* 1	* 1		5	124	168
Delaware	38		* 1		1					1	41	11			* 2						1	14	55
Florida	1,111						85	* 1			1,197	* 1	* 1	* 1							2	5	1,202
Georgia	1,195		31	* 1	* 3		27	* 2			1,259	46		22	* 5	* 2					8	83	1,342
Idaho		64	169	* 1	* 1	254		29	98	24	640										6		646
Illinois							4			1	5	101	7	* 4	10		* 1		* 1	12	29	165	170
Indiana										1	1	238	44	29	24	* 3	99	* 1	* 14	40	73	555	556
Iowa			80								80	17	* 3					* 1	* 4	12	15	52	132
Kansas																				* 1	4	5	5
Kentucky	38		5	27	* 2		6	* 1			79	406	* 9	150	42	36	37	* 1	* 10	* 10	81	782	861
Louisiana	2,737						609				3,346	75		* 1	84		* 1			* 1	94	206	3,552
Maine	13		383	110	421			15		52	994	19	17				* 10	68	* 4	* 1	4	118	1,112
Maryland	97		5	21	6		* 2				181	72	* 6	* 5	* 4	32	* 8	* 1	* 2	* 1	11	137	308
Massachusetts	6		223	25	37						291	14	* 6			29	* 5	* 9	* 1		6	70	361
Michigan			258	615	22			18	45	9	967	40	543				111	64	69	58	38	923	1,890
Minnesota			1,309	* 16	79			* 2	64	10	1,480	16	* 2					* 10	20	15	19	82	1,562
Mississippi	2,115						41				2,156	169	* 1	26	121		* 1		* 1	* 6	91	416	2,572
Missouri	142						33	* 3			178	272	* 10	* 2	84	* 2		* 1	* 1	28	82	482	660
Montana		43	* 2		* 7	147			104	5	308										1	1	309
New Hampshire	18		243	67	253					12	593	16	8			* 4	8	14	* 2		5	57	650
New Jersey	16							8		1	25	18		* 1		15					3	37	62
New Mexico		5			4	83					92												92
New York			105	163	128					9	405	37	75	* 2		* 19	42	33	36	16	17	276	681
North Carolina	1,575		97	40	* 24		34	* 6			1,776	209	* 6	74	31	50	* 1	* 1	* 6		24	402	2,178
Ohio	1			8						1	10	259	44	42	* 2	* 16	49	* 1	* 16	33	71	538	548
Oklahoma	142										142	61			* 3					* 2	18	84	226
Oregon		1,582		* 25	57	170		* 27	* 22	13	1,896		* 1								2	3	1,899
Pennsylvania	33		92	687	* 7					2	821	297	92	* 15	* 1	108	57	23	* 13	* 5	32	642	1,463
Rhode Island	* 1		11							2	14	4				7						11	25
South Carolina	797		* 8	* 1	* 14		36				856	11		8	15	* 1					7	42	898
South Dakota						30					30										1	1	31
Tennessee	117		36	36			9	9		1	208	546	* 9	165	76	72	* 18	* 1	* 11	* 11	107	1,016	1,224
Texas	2,019						* 2			1	2,022	47			19						11	77	2,099
Utah		* 1			2	7				2	12										1	1	13
Vermont	* 3		43	62	128					12	248	12	28			* 1	16	33	11	* 2	5	103	351
Virginia	1,222		96	42	80		* 5	* 15			1,460	388	* 6	115	* 14	68	* 2	* 1	* 10		38	642	2,102
Washington		3,061	* 34	103	165	266		184	* 40	8	3,861										2	2	3,863
West Virginia	16		26	280	248						565	456	54	155	* 3	120	37	* 15	30	* 1	37	908	1,473
Wisconsin			612	709	* 21			* 6	47	4	1,399	84	110				* 9	180	134	75	84	626	2,025
Wyoming						15				13	28												28
All other						11					11												11
Total	16,275	4,857	3,900	3,050	1,745	1,500	1,476	344	420	330	33,897	4,414	1,106	859	708	665	509	452	399	344	1,157	10,613	44,510

* Not shown on diagram because the production within the State is relatively small in comparison with other kinds.
All other—No. 10 and No. 20—also include small unclassified quantities of the specified kinds.

in thickness. For rotary cutting there are 35 thicknesses, the minimum being one-fiftieth of an inch, and the maximum the same as that for the other two processes. The term *veneer* includes much besides the ornamental covering used in cabinet-making; a great deal of the timber prepared in this way is used for baskets, packing cases, etc., and for the "built-up" stock already referred to.

The remaining employments of forest products noticed in this report are for poles and other electrical fixtures, for distillation and for the extraction of turpentine and rosin. For poles alone the telephone and telegraph companies in 1909 paid $4,081,251 out of a total of $7,073,826. The other purchasers of this kind of stock were of course railroad and electric light and power companies. Much the same distribution of purchasers is, naturally, observed in regard to cross arms and brackets.

The wood-distillation industry, whether hardwood or softwood, "is concerned with the manufacture of such products as result from the heating of wood so as to produce volatile distillates and solid residue." In one process the wood is heated to such a temperature as to destroy the fiber in order to form the new product; in the steam process the fiber is not destroyed. The distillation of hardwoods is carried on chiefly in Michigan, New York and Pennsylvania; that of softwoods, chiefly in Alabama, Florida and Georgia. In the distillation of hardwoods, the heating, or destruction, process is generally employed, producing, besides crude wood alcohol, charcoal and gray acetate. The value of hardwood distillation products reported for 1909 amounted, in all the United States, to $7,641,690, Pennsylvania leading with $2,939,960; softwood distillation in the same year, being "still to some extent in an experimental stage," produced only $58,317. One of the products of softwood distillation reported is tar, another is turpentine. The latter substance is, with rosin, the subject of an appendix to the report. The product of the two ordinary methods of extraction was, in 1909, 28,941,000 gallons of turpentine and 3,258,000 barrels of rosin, all this output being from Southern states, Florida leading. "Until recently the comparatively crude and wasteful box method was universally employed in procuring the gum from the trees, but . . . at the present time [1909] 13 per cent of the trees are treated by the cup system."

Ready-made Houses

Modern steel building construction methods have been adapted in a unique way to the construction of dwellings, bungalows, and other types of frame structures. The application has been in the manner of construction rather than the materials used. Results obtained are striking and in some ways almost revolutionary.

As is well known all the material for the steel framework of modern office buildings is manufactured, sized, cut to exact lengths, shaped and numbered at the steel mills, ready for assembling, erecting, and bolting in place on the job. No further cutting or fitting is necessary after leaving the mills. Naturally this greatly facilitates the rapid and accurate progress for which this type of construction is noted.

Exactly this same system is now applied to the construction of a ten-room frame dwelling. Every piece of lumber in the house is first figured out in shape, size, length, breadth, and thickness by expert designers and draftsmen. These figures are turned over to skilled carpenters, operating fast machinery in the factory. The time-honored ways of the hand saw are eliminated and every cut, miter, and bevel is accomplished by machinery. Every piece of lumber is numbered and marked by a surprisingly simple system and the house, for it is a house now, is loaded into the car and shipped to destination. Everything for the complete house is included in the shipment at a stated price, except the masonry; all sills, joists, studding, rafters, siding, sheathing, flooring, porch work, stairways, windows, doors, frames, moldings, locks, hinges, nails, paint, oil and varnish, putty, shingles, lath, and plaster, in fact everything is included at a plainly stated price.

The ready-cut system of construction was first brought to public attention 7 years ago, since which time is has made wonderful progress. It practically eliminates the necessity for skilled laborers in erecting dwellings and cuts the usual time of erection in half—and at a proportionate saving in cost.

There are several firms selling material for houses by mail, but only one manufactures houses complete by the ready-cut system—The North American Construction Company, of Bay City, Mich., who are exclusive manufacturers of Aladdin houses—*Mines and Minerals.*

The Metals in Antiquity

In his Huxley memorial lecture Prof. W. Gowland traced the origin of the smelting furnace to the camp fire, in which, if by chance a lump of ore either of copper carbonate, tin-stone, or brown iron ore or hematite, had been one of the ring of stones surrounding the camp or domestic fire and had accidentally become embedded in its embers, it would undoubtedly be reduced to metal.

The metals which occur—native copper, gold, and iron—were undoubtedly the first to be known to man in the localities in which they occurred, but until the art of smelting metals had been invented, the discovery and use of the native metals was insufficient to affect to any great extent the old Stone age culture.

Gold, although doubtless the first metal to be known in many localities owing to its wide distribution in the sands of rivers, was useless for any practical purpose.

Copper, however, or an alloy of the metal with tin, antimony, or arsenic, was extracted from ores at a very remote period, and it or its alloys was the first to be applied to practical use. In fact, the first metal to be obtained by primitive man by smelting copper ores depended on their composition, and in the localities where tin did not occur it was a more or less impure copper.

The extraction of gold from its ores on a large scale in the earliest times was attributed to the Sudan district of Egypt.

Egypt is also noted for having produced the first mining map in the world, a map showing a gold mining region of the time of Seti I or Rameses II (1350 to 1330 B. C.).

The influence of silver and lead on the development of primitive culture was shown to be insignificant, the latter metal only becoming of importance during the supremacy of the Romans, in connection with their elaborate systems for the supply and distribution of water and in the construction of baths.

As regards iron, the belief that the first iron generally known to man was either of meteoric origin or telluric native iron is not supported by any substantial evidence. Nor is such origin necessary, as iron ores are so easily reducible that they can be converted into metallic iron in an ordinary charcoal fire. They are, in fact, reduced to metal at a considerably lower temperature than the ores of copper.

The earliest iron smelting in Europe has been traced to the upper waters of the Danubian tributaries, the ancient Noricum, but in still earlier times iron was extracted from its ores in the region on the southeast of the Euxine, in Ferghana and other localities in Asia. In Africa, so far as metallurgical evidence may be depended on, the extraction of iron from its ores was carried on at a remote date. That this early African iron smelting was known in Egypt is well shown by a bas-relief on a stone now in the Egyptian collection in Florence.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

The Use of Ammonia in Bringing Metal Into Solution

To the Editor of the Scientific American Supplement:

Cobalt and copper can be detected in the metallic state by the following method: An oxidizing agent is added to a solution of ammonium hydroxide, and the mixture is put in contact with the metal to be tested. Gas is given off until the oxidizing agent in solution is exhausted.

If the metal tested is cobalt, the resulting solution shows the brown or reddish color of cobaltic ion, and if the metal is copper, the solution takes on the deep blue of cupric ion.

It does not matter whether the metal tested is pure, or alloyed, it is always ionized freely, as copper ion can be obtained in this way from brass or bronze, German silver, and even from nickel coins which contain copper.

Cobalt and copper both form complex ions with ammonia, and have the following formula: cobaltic, $Co(NH_3)_6^{++}$—cupric, $Cu(NH_3)_4^{++}$.

The metals in the reactions described above are probably first formed into oxides and then form hydroxides, which are dissociated in solution and form complexes with ammonia in solution as follows:

$$\begin{gathered} Co(OH)_2 \rightleftarrows Co^{++} + 2OH^- \\ 6NH_4OH \rightleftarrows 6NH_3 + 6H_2O \\ \downarrow\uparrow \\ Co(NH_3)_6^{++} \end{gathered}$$

$$\begin{gathered} Cu(OH)_2 \rightleftarrows Cu^{++} + 2OH^- \\ 4NH_4OH \rightleftarrows 4NH_3 + 4H_2O \\ \downarrow\uparrow \\ Cu(NH_3)_4^{++} \end{gathered}$$

The reactions are usually very rapid, and the color of cobaltic or cupric ion can be seen in a second or two, if a good oxidizing agent is used. Various oxidizing agents will answer but hydrogen peroxide is one of the best, as it gives up oxygen very readily and is colorless in solution, and some others are too slow.

If the experiment is tried with powdered metal the reaction takes place with the evolution of considerable heat and with great speed, owing to the large amount of surface of metal available for oxidation.

Cupric ion cannot be detected by color in the presence of much cobaltic ion, and *vice versa.*

In a case where cupric and cobaltic ion are both present in nearly equal amounts, it would be necessary to precipitate the cupric ion in an acid solution with hydrogen sulphide to separate the two.

Metallic zinc also can be brought into solution by means of an oxidizing agent and ammonium hydroxide, but as zinc ion in solution is colorless it would be necessary to precipitate it with hydrogen sulphide in order to detect its presence in a solution. C. D. King.

Lyndhurst, N. J.

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Title pages for the last volume of the Scientific American, the Scientific American Supplement, and American Homes and Gardens will be sent free of charge to those subscribers of the three periodicals in question who may wish to bind up the numbers of the last volume.

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The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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